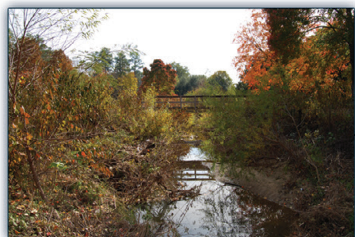
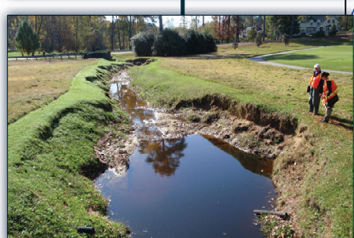
Volume II • Main Plan

Durham Third Fork Creek Watershed Management Plan

December 2012





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CITY OF DURHAM Stormwater Services

TETRA TECH

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Acronyms and Abbreviations

BMP	best management practice
BOD	biochemical oxygen demand
BSD	Better Site Design
CAPP	Critical Area Protection Plan
CIP	capital improvements program
DO	dissolved oxygen
DWQ	Division of Water Quality (North Carolina)
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	geographic information system
HSG	hydrologic soil group
JFLSLAT	Jordan/Falls Lake Stormwater Load Accounting Tool
LA	load allocation
LID	low impact development
MOU	memorandum of understanding
MS4	municipal separate storm sewer system
NCBI	North Carolina Biotic Index
NCCU	North Carolina Central University
NPDES	National Pollutant Discharge Elimination System
POTW	publicly owned treatment works
RAMP	Riparian Area Management Plan
RGD	Reference Guide for Development
SCM	stormwater control measure
SCR	stream corridor restoration
SSO	Sanitary Sewer Overflow
SWMM	Storm Water Management Model
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
UDO	unified development ordinance
WLA	wasteload allocation
WMP	watershed management plan
WMIP	watershed management improvement plan
WQRP	Water Quality Recovery Plan

Glossary

assessment	an evaluation to determine the importance, size, or value
best management practice (BMP)	schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to waters of the United States; see SCM
Better Site Design (BSD)	a collection of site planning, design, and development strategies that help reduce adverse impacts to the natural environment by recreating, to a certain extent, the original hydrology and plant community of the predevelopment site
biochemical oxygen demand (BOD)	measurement of the amount of oxygen used in the decomposition of organic material, over a specified time period (usually 5 days) in a wastewater or stormwater sample
buffer	something that lessens or absorbs negative effects; see riparian buffer
catch basin	part of the stormwater drainage system that temporarily holds runoff from a specific area (usually a concrete box with a grate where a storm drain empties into the sewer), a catch basin may be used to catch large items that might block the flow in the stormwater sewer
concentrated flow	runoff that accumulates or converges into well-defined channels
diffuse flow	surface runoff flow that is spread out and slowed down to help prevent erosion and protect water quality
discharge	volume rate of stormwater or wastewater flow
illicit discharge	a discharge to a stormwater drainage system that contains anything not specifically allowed by an NPDES permit (whether direct or indirect)
dissolved oxygen (DO)	the amount of oxygen freely available in a body of water – dissolved oxygen is important for a balanced aquatic ecosystem
drainage system (stormwater)	a system of natural and manmade drains, pipes, ditches, and waterways (such as creeks, streams, rivers, wetlands, ponds, and lakes) that collect and carry stormwater—drainage systems can be owned publically or privately

easement	a legal agreement that gives a right to a person or group to make limited use of another's property (examples include having a road on another's property to reach your own or a utility easement where pipe or power lines run through a property)
erosion	a process where water wears away soil and dirt from the land carrying it to water
evaporation	the process where the heat from the sun causes liquid water to become water vapor
evapotranspiration	a combination of evaporation and transpiration
flood / flooding	when a normally dry area becomes covered in water or another liquid
floodplain	an area likely to be covered by rising water (can be outside a FEMA mapped floodplain); also known as flood prone area
floodplain: 100 year	a flood that has a 1 percent chance of occurring in any year
floodplain: 500 year	a flood that has a 0.2 percent chance of occurring in any year
floodway	according to FEMA: where floodwaters are likely to be deepest and fastest, the area of the floodplain that should be kept free of obstructions to allow floodwaters to move downstream
filter	a porous media used for removing impurities or solids from stormwater or wastewater
geographic information system (GIS)	a system used to capture, store, analyze, and display data linked to geographic locations
groundwater	water that filters into the soil and either flows to an aquifer or returns to surface waters; can be shallow or deep
impervious surface	a surface that does not allow water to soak in, usually hard; examples: roofs, roads, and parking lots
infrastructure	the basic physical and organizational structures and facilities (e.g., buildings, roads, utilities) needed for the operation of a society
infiltration	the slow seeping of rain water into the soil
low impact development (LID)	a land planning and engineering design approach to managing stormwater runoff that emphasizes conservation and use of on-site natural features to protect water quality
management, stormwater	controlling the amount and content of stormwater

municipal separate storm sewer system (MS4)	a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) designed or used for collecting or conveying stormwater, and neither includes wastewater nor is connected to a publicly owned treatment works (POTW)
non-point source	water pollution affecting a water body that originates from many, diffuse sources and is difficult to identify and prevent
non-structural control	source-control programs, policies, techniques, etc., that reduce the amount of stormwater pollutants in stormwater runoff by primarily seeking to change human behavior
nutrients	regarded as a pollutant in stormwater runoff; means a chemical element or compound, such as nitrogen or phosphorus that is essential to and promotes the development of organisms
peak flow	maximum volume rate of runoff during a storm event
pervious surface	a surface that allows water to soak in; examples: planted area of ground, forested areas
pollutant/pollution	generally, something that damages or contaminates air, water, or soil
reservoir	a man-made lake used to store water for uses such as a drinking water supply
riparian	an area next to the banks of streams, rivers, lakes, or other bodies of water
riparian buffer	an area with plants and trees next to a body of water that helps protect water quality by filtering pollutants from runoff
runoff	rain or snow melt that does not filter into the soil but instead flows into nearby drains or bodies of water
sanitary sewer	the sewer system that takes used water from sinks, showers, and toilets to the wastewater treatment plant; in Durham the stormwater sewer is separate from the sanitary sewer; also can include waste from commercial and industrial operations
sediment	material worn away from the landscape (such as soil and bits of rock) by water, wind, or ice
screening	the evaluation of a group using a methodical survey to assess suitability for a particular purpose

storm drain	an opening to the stormwater sewer that moves rain or melted snow that does not soak into the ground to a nearby stream, river, or lake
stormwater	water that flows over the land after it rains or snow melts
stormwater control measure (SCM)	any structural or nonstructural strategy, practice, technology, process, program, or other method intended to control or reduce stormwater runoff and associated pollutants, or to induce or control the infiltration or groundwater recharge of stormwater or to eliminate illicit or illegal non-stormwater discharges into stormwater conveyances; see BMP
stormwater drainage system	infrastructure of curbs/gutters, catch basins, manholes, culverts, ponds, etc. used to collect and convey stormwater to its point of discharge; can include SCM's
stream channel	a long, narrow low area a stream usually flows through; includes the bed of the stream and its banks
stream corridor restoration (SCR)	actions and measures designed to enable stream corridors, both the stream channel and adjoining riparian area, to recover dynamic equilibrium and function at a self-sustaining level
structural control	facilities that reduce the quantity or improve the quality of stormwater at or near its source, commonly through filtration, infiltration, and detention. Examples: swales, buffer strips, wetlands, wet/dry ponds, bioretention, permeable pavement
sustainable	conserving an ecological balance by avoiding the depletion of natural resources
total maximum daily load (TMDL)	sum of the individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background under the federal Clean Water Act
total suspended solids (TSS)	measured of combined settleable and non-settleable solids in stormwater and wastewater
toxic	able to cause injury or even death usually by means of a poisonous chemical
transpiration	a process where water vapor is released from a living organism such as through the leaves of a plant or the pores of an animal
unified development ordinance (UDO)	a set of regulations that consolidates most of the requirements that apply to development from both the City of Durham and Durham County

velocity	how fast water flows in a given direction during a specified time
vegetation	plants; trees, shrubs, and grass
wastewater	any water that has been adversely affected in quality by anthropogenic influence; often refers to domestic or industrial waste streams
water body	an accumulation of water such as a river, lake, stream, or ocean
watershed	land areas and their network of creeks that convey stormwater runoff to a common body of water
waterway	navigable body of water such as a river, channel, or canal

1 Introduction

1.1 Stewardship of Third Fork Creek Watershed

The City of Durham's vision is to be the leading city in providing an excellent and sustainable quality of life (Durham Strategic Plan, 2012 annual report). Consequently, the mission of City staff is to provide quality services to make Durham a great place to live, work, and play. For Durham's Stormwater Services Division, this means managing stormwater runoff to restore and protect the City's water resources. Stormwater management is most effective when viewed in the watershed context—watersheds are land areas and their network of creeks that convey stormwater runoff to a common body of water.

In 2007, the City launched a watershed management planning process to proactively address changes the City is making to comply with water quality regulations, to improve the health of the streams draining the City, and create value for neighborhoods in the City's watersheds. As a part of that process, the City is finalizing a watershed management plan (WMP) for Northeast Creek and Crooked Creek and has completed one for Ellerbe Creek. This WMP was developed for the Third Fork Creek watershed.

The Third Fork Creek WMP will primarily support these three goals of the City's Strategic Plan:

Strategic Plan Goal 3: Thriving livable neighborhoods

Strategic Plan Goal 4: Well-managed city

Strategic Plan Goal 5: Stewardship of the City's physical assets

The Strategic Plan calls for the City to modify wastewater treatment plant and stormwater discharge processes to meet water quality standards. Any changes in surface water quality progress will be measured using a Water Quality Index based on monitoring data collected and assessed by the Stormwater Services Division. The WMP characterizes watershed resources and water quality, and identifies high-priority areas in the watershed that need restoration and protection, and specific management actions to improve water quality of Third Fork Creek.

A key to environmental stewardship is to identify, prioritize and implement stormwater management projects to help achieve the City's multiple goals. The Strategic Plan notes that part of being a *well-managed city* (Goal 4) is periodically reviewing and updating the multiyear financial plan and the Capital Improvements Program (CIP) to align resources with priorities and to identify and prioritize unfunded CIP needs. Therefore, one of the primary reasons for developing this WMP is to identify, evaluate, and prioritize watershed restoration and protection projects and actions to be incorporated in the City's CIP and financial plan.

1.2 Organization of the Third Fork Creek Watershed Management Plan

The WMP is organized into three volumes:

1. **Volume I – Executive Summary**. This brief document describes the approach for developing the WMP, key findings of the assessment of watershed conditions, existing efforts that provide a current base or foundation for watershed management, project prioritization criteria, high-priority watershed improvement projects (see Table 6 and Figure 11 in Volume II) and actions recommended, and the associated costs and benefits of implementing the WMP.
2. **Volume II – Watershed Management Plan**. The main report summarizes the methods for developing the WMP; describes the character of the watershed (such as current land use); discusses water quality issues and the primary forces negatively affecting water quality; states the goals and objectives of the WMP; highlights existing management efforts in the watershed; shows watershed improvement opportunities; and describes a plan for implementing the high-priority projects and actions.
3. **Volume III – Technical Appendices**. A series of memoranda and reports prepared throughout the project are included in Volume III. They describe in more detail the technical approaches used and results of the analyses.

1.3 Introduction to the Third Fork Creek Watershed

The Third Fork Creek watershed is in southern Durham County, North Carolina (Figure 1). Third Fork Creek flows through the heart of many City of Durham neighborhoods such as Tuscaloosa-Lakewood, St. Teresa, Forest Hills, Hope Valley Farms, and Woodcroft, down to New Hope Creek that flows into Jordan Lake. The northern boundary of the watershed is in downtown Durham, just north of NC 147, or the Durham Freeway. The southern boundary is just north of Interstate 40. The watershed covers an area of 16.6 square miles.

The Third Fork Creek watershed drainage includes a significant portion of the older and highly urbanized downtown section of the City. Much of the development of this portion of the City occurred before consideration was given to effects of development on water quality and watershed resources. As a consequence, water quality is impaired in several areas of the watershed. Section 2 of this WMP summarizes the findings of detailed watershed characterization conducted for Third Fork Creek. This characterization helped to identify and prioritize the most important issues to address and guide development of specific management goals and objectives (summarized in Section 3) and locate specific opportunities throughout the watershed for improving water quality through protection and restoration of watershed resources (Section 5 of the WMP).

Because Third Fork Creek drains to the Upper New Hope Arm of Jordan Lake, it is subject to regulatory requirements stemming from the total maximum daily load (TMDL) and nutrient management strategy for controlling nutrients to meet the state chlorophyll *a* standard established for Jordan Lake. This standard and associated strategy was enacted by the North Carolina Environmental Management

Commission in 2009 and is administered by the North Carolina Division of Water Quality (DWQ). Management actions recommended in this WMP were shaped and developed to help the City comply with these regulatory requirements. Methods for developing the Third Fork Creek WMP are summarized in Section 1.4.

1.4 Method for Developing the WMP

To develop the Third Fork Creek WMP, the City established a Coordination Team composed of staff from multiple departments and groups. The team worked together and with the consultant, Tetra Tech, throughout the process. A stepwise approach was conducted beginning with review of existing data on the watershed and its water quality. On the basis of that review and additional analysis using a geographic information system (GIS), field survey information in the primary areas of concern was collected. Field data and observations were used to identify problem areas, specifically identifying stream channel stability and riparian area condition (i.e., condition of the land adjacent to the stream channel and in the floodplain), infrastructure crossings, illegal dumping, illicit discharges, and invasive species. Potential sites for stream channel and riparian buffer restoration were noted, and the City's existing Riparian Area Management Plan (RAMP) was updated. Additional field data was collected in selected upland areas, where overland flow of stormwater enters streams, to identify potential stormwater concerns and opportunities for managing stormwater runoff volume and water quality.

Next, a watershed water quality model—Storm Water Management Model (SWMM)—was set up for Third Fork Creek. The US Environmental Protection Agency (EPA) SWMM model, first developed in 1971, has undergone numerous updates and enhancements, and is designed for storm event flow management in urban drainage systems. The model for Third Fork Creek was calibrated and validated with observed data for flow and water quality collected in the watershed. The model allows for the City to better understand the relationships between land use and land cover, stormwater management practices, and the resulting runoff volume and pollutants that can impact Third Fork Creek and downstream Jordan Lake. The model included a simulation of existing, on-the-ground stormwater control measures (SCMs) to evaluate their ability to manage runoff volume and pollutants. The modeling results helped identify those areas in the watershed generating the highest loads for pollutants of concern.

The combination of results from the existing data review, GIS analyses, stream surveys, upland surveys, and SWMM modeling were used to identify and prioritize management areas in the Third Fork Creek watershed. Opportunities for upland stormwater retrofits (i.e., constructing new or modified SCMs on existing developed land where no or inadequate treatment exists) and stream and buffer restoration projects were evaluated and ranked accordingly. Additionally, existing undeveloped lands found to be critical to the future protection of water quality and watershed resources were identified and prioritized in a Critical Area Protection Plan (CAPP).

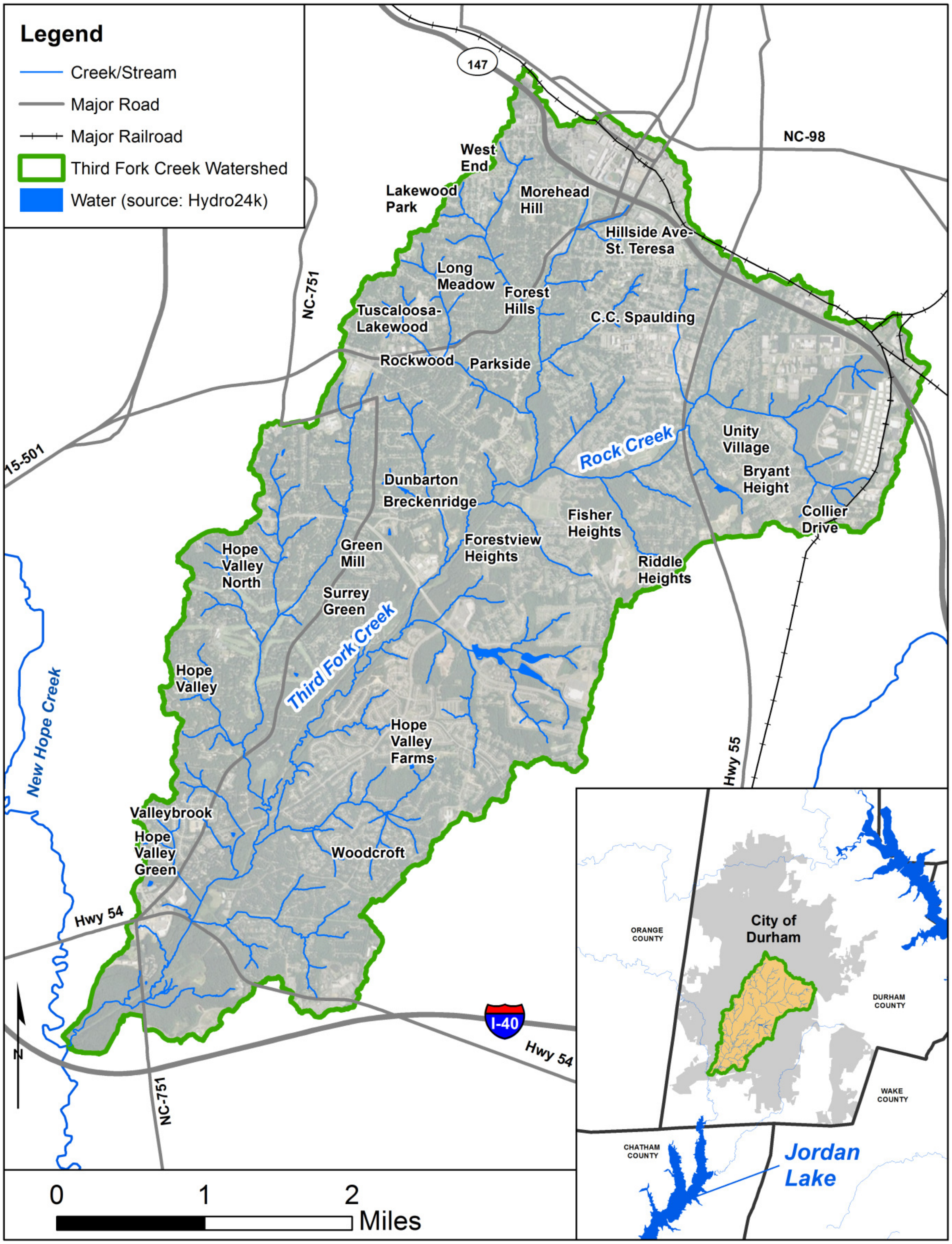

Figure 1. Third Fork Creek Watershed in South Durham

A subset of the prioritized SCM and stream restoration projects was selected to develop preliminary engineering or conceptual designs for implementation consideration. These project designs (with preliminary cost-benefit evaluations) will provide the opportunity for the City to determine whether the selected projects merit inclusion in the City's CIP and financial plan. Additionally, an existing City property was selected and is being evaluated for potential application of Better Site Design (BSD)/Low Impact Development (LID) concepts.

In addition to management recommendations specific to the Third Fork Creek watershed, policies and procedures were reviewed for a number of services that pertain to City-wide programs. Local stormwater codes, ordinances, policies, and procedures were reviewed for potential refinement needs. Similarly, SCM maintenance standards, protocols, and policies were reviewed for areas of potential refinement.

Public outreach and education was another important component of this WMP. Results of the watershed characterization and selection of management opportunities were shared with interested members of the public through newsletters, three public meetings, and updates on the project webpage (http://durhamnc.gov/ich/op/pwd/storm/Pages/stormwater_thirdfork.aspx) and the Stormwater Services Facebook page (https://www.facebook.com/durhamncstormwater). Public input was received from stakeholders on potential enhancements to watershed management in the Third Fork Creek watershed and incorporated into the WMP, as feasible.

The final step of the WMP was the development of an implementation strategy for the identified recommendations.

An overview of field and planning efforts conducted for Third Fork Creek is provided in this WMP. Additionally, an executive summary has been prepared to summarize and help communicate the WMP to a broader audience. Finally, the technical memos and reports prepared during the planning process were compiled into a set of appendices to provide long-term reference for those interested in more detailed information.

2 Watershed Characterization

The phrase *watershed characterization* generally refers to the process of obtaining and evaluating information on the physical, chemical, and ecological conditions in a watershed to develop an understanding of its overall health and the issues most in need of management. This section of the WMP summarizes the findings for Third Fork Creek on the basis of three components of assessment:

1. Initial review and preliminary characterization of existing data from the City and other sources
2. Field assessment including upland, riparian, and stream components
3. Watershed modeling to aid in understanding of existing and future watershed conditions (particularly pollutant loading and stormwater runoff volume) and the impact of structural SCMs

The Third Fork Creek watershed was divided into 60 subwatersheds, averaging about 177 acres, as a basis for organizing and evaluating data. To help with summarizing and communicating the characterization results, the subwatersheds were grouped into six drainage areas on the basis of name and location: Lower Third Fork Creek, Middle Third Fork Creek, Rock Creek, Third Fork Creek Headwaters, Third Fork Creek Tributary, and Upper Third Fork Creek (Figure 2). The sections below summarize the results of the characterization using these subwatersheds and groupings.

2.1 Geology and Land Cover Influences on Water Quality

A key defining natural characteristic of the Third Fork Creek watershed (that greatly influences water quality) is its soil properties that are different than other areas of Durham County. Third Fork Creek is entirely within the Triassic Basin, with a parent geology dominated by sedimentary mudstones and siltstones. As a result, the soils derived from the mudstones and siltstones tend to be fine-grained with a high clay content and low permeability and thus generate higher volumes of stormwater runoff than soils with a higher infiltration capacity.

Another key characteristic of the watershed is the degree to which land has been converted from forest to development or road networks. Land use and land cover determine many aspects of the watershed's overland wash off of stormwater, pollutant loading to the streams, and the hydrologic response of streams and creeks from increases in stormwater volume and velocity. Land cover in the watershed is a suburban/urban mix of deciduous and evergreen trees, turf grass, wetlands, and impervious surfaces. Approximately 48 percent of the Third Fork Creek watershed is devoted to residential uses, half of which are considered low density. Nearly eight percent of the watershed is classified as commercial or industrial land use. Most of the nonresidential, developed land uses are in the Third Fork Creek headwaters and the Rock Creek area. The watershed's existing land use/land cover is mapped on Figure 3.

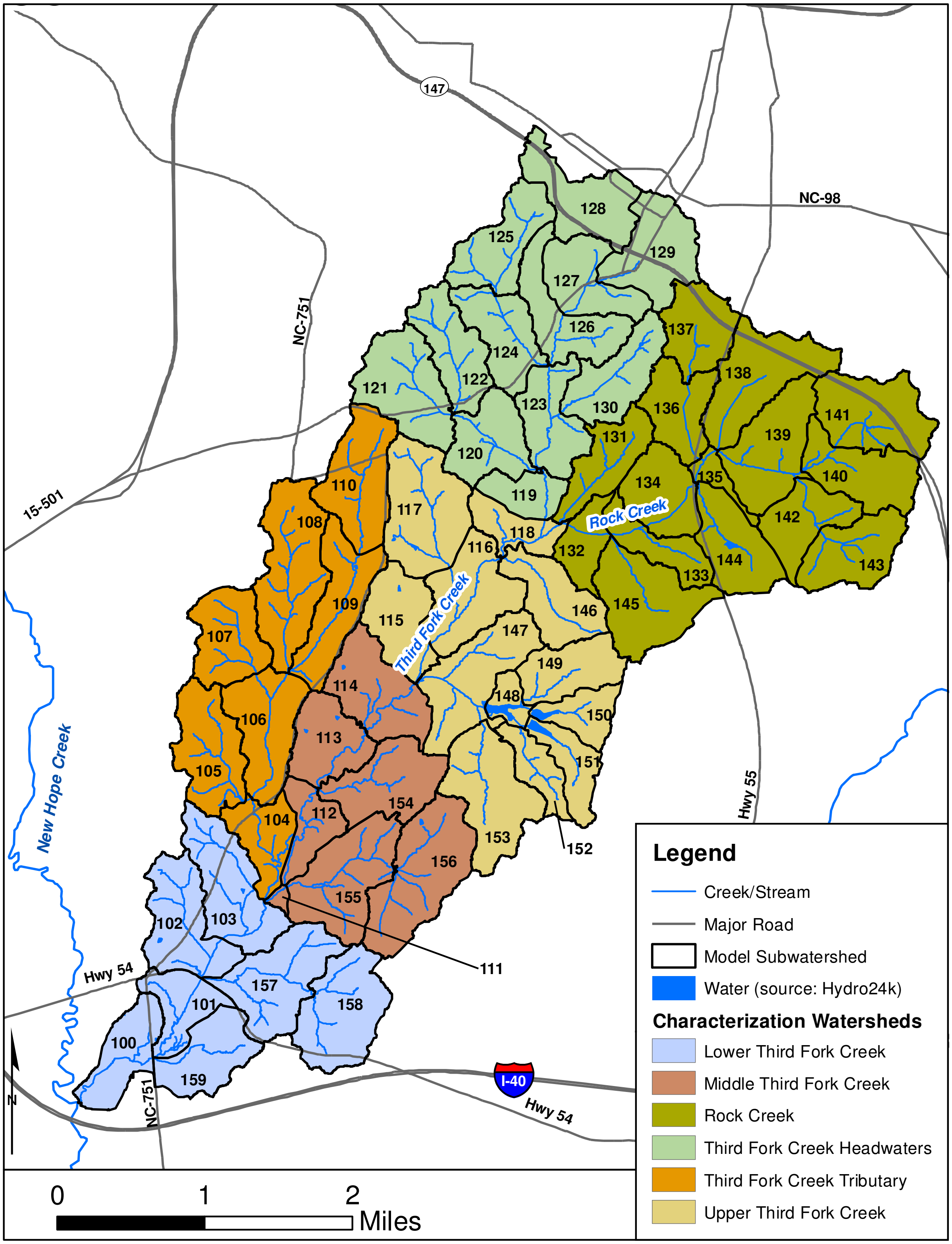

Figure 2. Third Fork Creek Assessment Subwatersheds

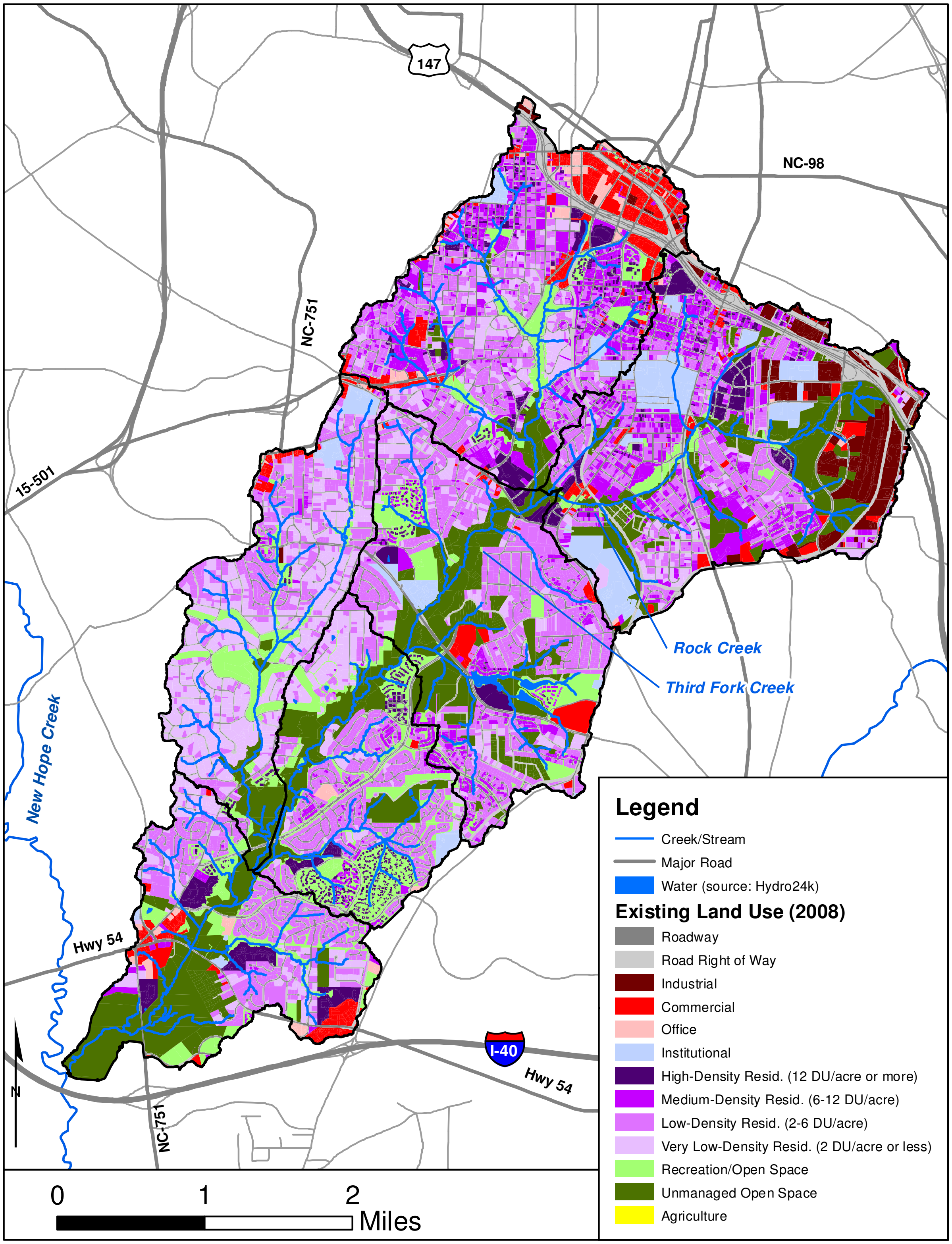

Figure 3. Existing Land Use and Land Cover in the Third Fork Creek Watershed

2.2 Key Water Quality Issues

When water quality does not meet water quality standards more than 90 percent of the time or when the water body has poor biological conditions, the North Carolina DWQ can designate the water body segment as *impaired*. Third Fork Creek's impairments are typical of an urban watershed with multiple stressors. A stressor can be a physical, chemical or biological agent (or any combination), environmental condition, external stimulus or an event that causes stress to the health of the water body. The watershed's stream impairment history is summarized in Table 1.

Table 1. Impairments for Third Fork Creek

Integrated Report Year	Locations[a]	Miles	Parameter
2002	2.0 miles upstream of NC Hwy 54 to New Hope Creek	3.6	Turbidity
	From source to 2.0 miles upstream of NC Hwy 54	5.1	Biological integrity
2004	2.0 miles upstream of NC Hwy 54 to New Hope Creek	3.6	Turbidity
	From source to 2.0 miles upstream of NC Hwy 54	5.1	Biological integrity
2006	From source to 2.0 miles upstream of NC Hwy 54	5.2	Biological integrity
2008	Source to New Hope Creek	9.1	Low Dissolved Oxygen
	Source to New Hope Creek	9.1	Ecological/Biological Integrity Benthos
	Source to New Hope Creek	9.1	Copper
2010	Source to New Hope Creek	9.1	Low Dissolved Oxygen
	Source to New Hope Creek	9.1	Ecological/Biological Integrity Benthos
	From source to 2.0 miles upstream of NC Hwy 54	5.1	Zinc
	2.0 miles upstream of NC Hwy 54 to New Hope Creek	3.9	Copper

[a] The location "2.0 miles upstream from NC Hwy 54" is in the Middle Third Fork Creek characterization watershed and corresponds to the transition from the state surface water classification Water Supply IV to Class C.

In 2005, North Carolina DWQ developed a TMDL to address the turbidity impairments in Third Fork Creek. The TMDL for the Third Fork Creek watershed assigns a total suspended solids (TSS) reduction target of 0.75 ton/day, a 53 percent reduction from the estimated existing load (using the years 2000 to 2003 to estimate the existing baseline load). The main sources of turbidity identified during the TMDL development were runoff from nonpoint sources, particularly land development activities for residential buildings, commercial areas, roads, and highways. As a condition of their 2007 municipal separate storm sewer system (MS4) permit, the City developed a *Water Quality Recovery Plan* (WQRP) to report to the state and guide its efforts to address the TMDL.

Because Third Fork Creek drains to the Upper New Hope Arm of Jordan Lake, it is subject to requirements of the Jordan Lake TMDL and nutrient management strategy for control of nutrients. According to the strategy, to restore the water body to its intended use, the Jordan Lake TMDL requires a 35 percent and 5 percent reduction in total nitrogen (TN) and total phosphorus (TP) loading, respectively, using the years 1997 to 2001 to estimate the baseline loads for the Upper New Hope Arm of the lake.

2.3 Primary Stressors

As with any watershed that has experienced significant suburban and urban development, the Third Fork Creek watershed has a number of forces exerting stress on water quality and habitat. Primary stressors in the watershed were evaluated through field observation and assessment, GIS analysis, and computer model simulation. The primary stressors are discussed below.

2.3.1 Impervious Area

The degree to which forest and natural areas have been converted to *impervious areas* in a watershed is an important factor in determining the amount and timing of runoff, streamflow characteristics, channel formation, and pollutant loading. Impervious surfaces encourage direct runoff rather than infiltration of precipitation into the soil. These surfaces include buildings, parking lots, roads, sidewalks, and other features. The total imperviousness for the watershed is estimated at approximately 25 percent (Table 2). A map of the impervious coverage is shown on Figure 4.

Table 2. Impervious Cover Statistics

Characterization Watershed	Percent Total Impervious Area
Lower Third Fork Creek	20.3
Middle Third Fork Creek	22.2
Rock Creek	30.0
Third Fork Creek headwaters	34.0
Third Fork Creek tributary	19.2
Upper Third Fork Creek	20.1
Entire Watershed	25.4

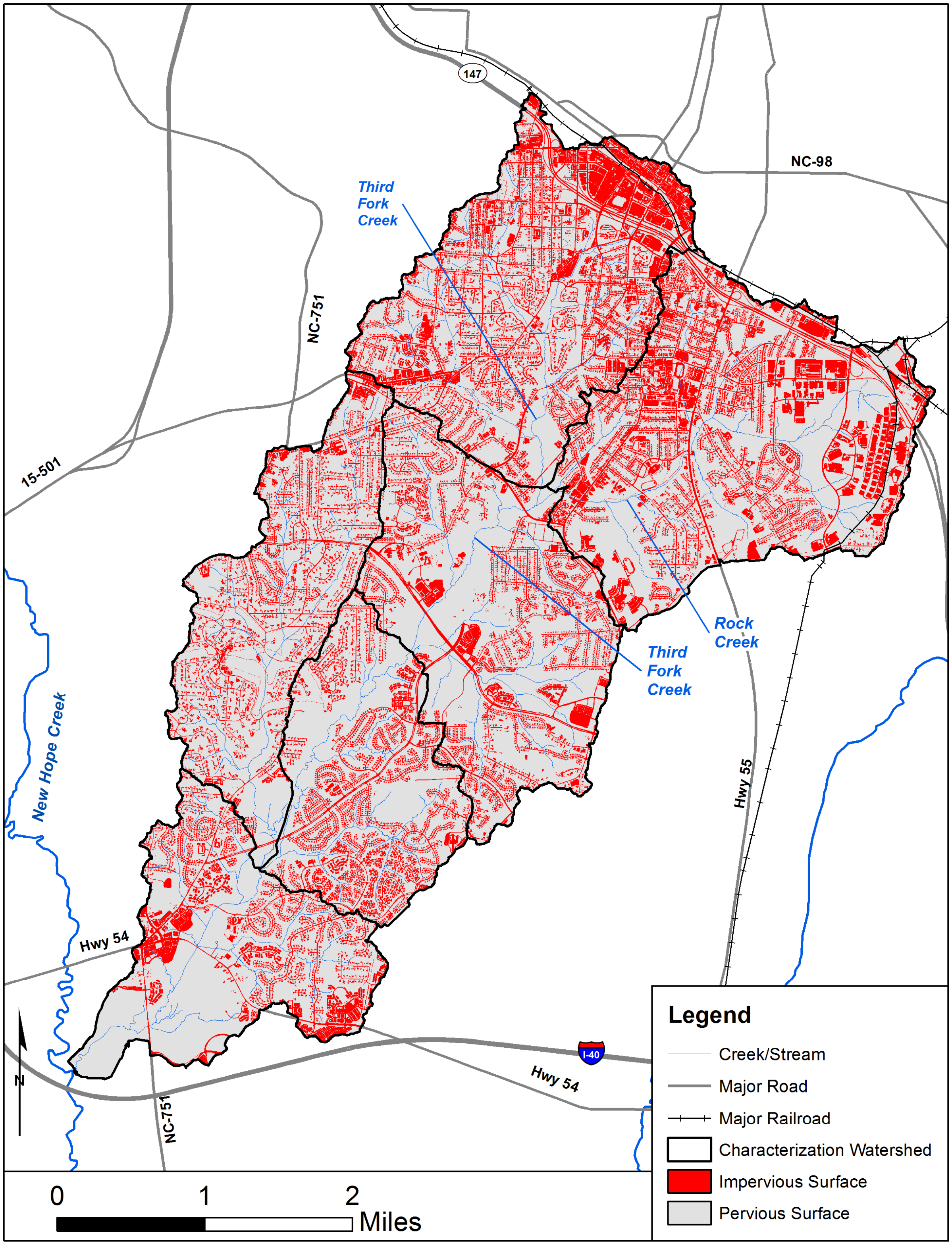

Figure 4. Impervious Cover

2.3.2 Stream and Riparian Area Stressors

A field assessment of stream and riparian areas in selected portions of the Third Fork Creek watershed was conducted to identify stressors. A total of 13.5 stream miles were surveyed in the watershed. Two different levels of assessment were performed, depending on the selected location. Level I assessments were conducted for five to seven stream reaches per day with approximately 1,000 feet assessed per reach. For Level I assessments, information collection on stream and habitat stressors included *streambank erosion, pollution sources*, *utility and infrastructure crossings*, *major dumping locations*, *overall stream and buffer/floodplain condition*, and any potential recommended restoration opportunities. Level II assessments were more detailed and were targeted for the segments of greatest concern on the basis of pre-field GIS analysis. Level II assessments were performed on three to four segments per day with each reach segment approximately 500 feet long. In addition to the stream and habitat stressor information gathered for the Level I streams, stressor information collected for Level II streams included *detailed descriptions of the location and condition of stormwater outfalls*, *riparian buffer impacts*, *severe bank erosion*, *stream crossings*, *utility impacts*, *trash and debris*, and *channel modifications*.

Three general types of field assessment scores were generated based on observed and measured conditions. First, the overall instream score was based on the sum of the in-stream habitat score, vegetative protection score, bank erosion score, and floodplain connection score. Second, the riparian buffer score was based on the sum of the vegetated buffer width score, the floodplain vegetation score, the floodplain habitat score, and the floodplain encroachment score. Third, a reach level score was generated based on the sum of the instream and riparian buffer scores. For more detailed information about the field assessment techniques and ranking, see Appendix B.

Stream reaches were assigned overall assessment scores on the basis of their condition. Reach level scores that ranged from 0 to 31 were considered to be in *Poor* condition and characterized as having no in-stream habitat/structure, no vegetative bank protection (reach could have riprap installed to prevent bank erosion), and no connection to the floodplain. Scores from 32 to 80 were considered to be in *Marginal* condition. Scores from 80 to 123 were considered to be in *Suboptimal* condition and scores from 123 to 160 were considered *Optimal.* Optimal reaches have sufficient in-stream habitat (e.g., large woody debris, undercut banks, and deep pools), are fully vegetated (i.e., near 100 percent cover) with little or no evidence of bank erosion, and are well-connected to the floodplain. Some of these optimal reaches are habitats that need to be protected. A summary of the scores is provided in Table 3. Results of the overall reach scores are displayed in Figure 5.

Table 3. Summary of Stream Scores

Assessment Type	Optimal	Suboptimal	Marginal	Poor	Total
Reach Level	8%	39%	35%	19%	100%
In-Stream	14%	34%	36%	16%	100%
Riparian Buffer	5%	36%	32%	27%	100%

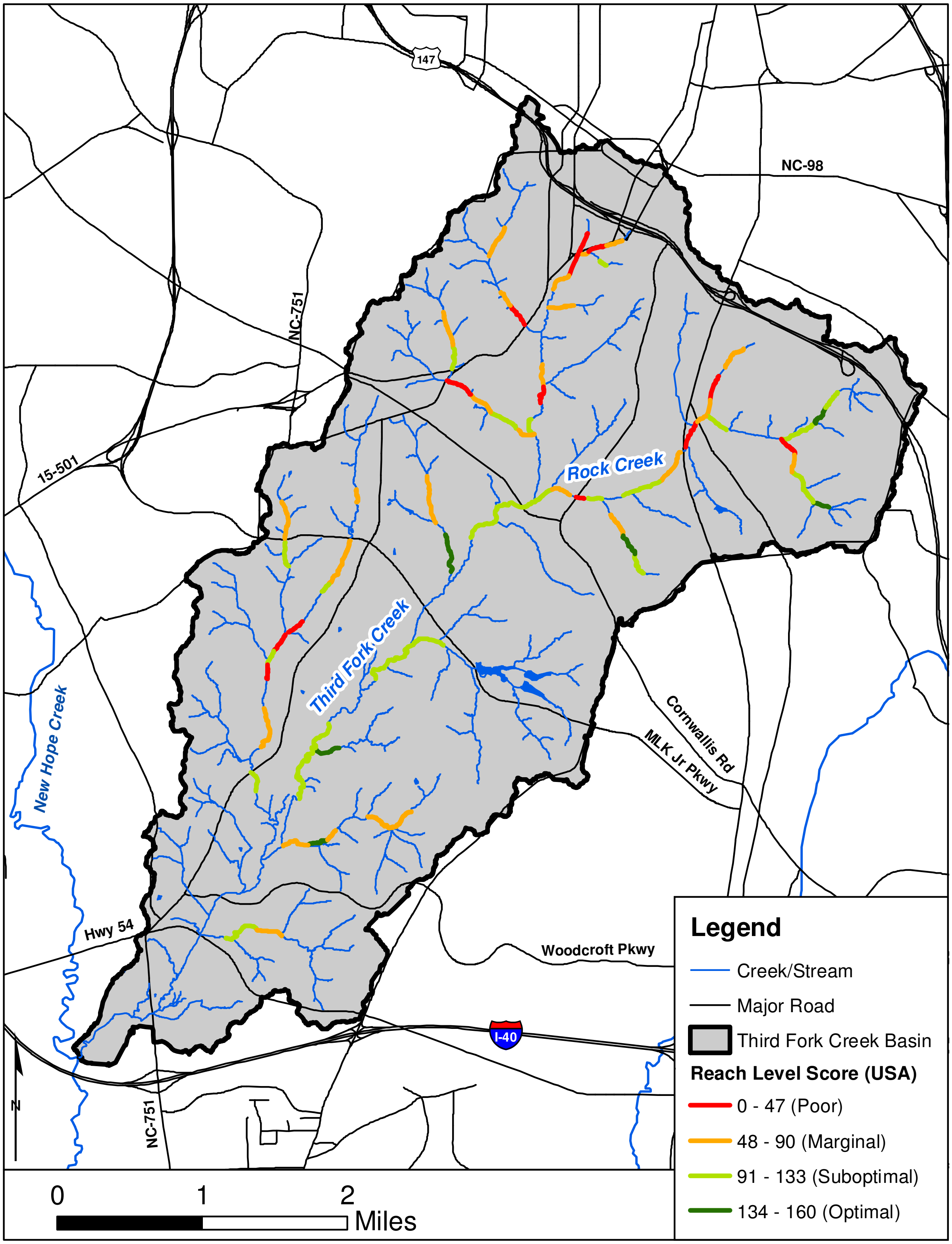

Figure 5. Reach Level Score for Overall Stream Channel Condition

Changes to stream channel dynamics and form (or geomorphology) are also significant stressors to water quality and habitat in the watershed. During field assessments, the following geomorphologic dynamics were observed in the watershed:

- Evidence of active channel incision (a steep deepening of the channel)
- Channel widening
- Sediment aggradation (excessive buildup) and scouring in portions of the channel
- Floodplain disconnection caused by active or historic channel incision
- Evidence of mass wasting—when streambanks fail and large quantities of sediment enter the stream

Active channel dynamics of incision, mass wasting, aggradation, and channel widening are occurring throughout the watershed. These changes in stream channel dynamics and form are indicative of upstream watershed development and changes in land use and land cover. Incision was present at 15 percent of reaches, and widening and mass wasting was observed in 44 percent and 29 percent of reaches assessed, respectively (Figure 6). The age (i.e., older development of more than 30 years) and density of development in the upper half of the watershed has contributed to the most channel degradation along the upper portion of Third Fork Creek, Rock Creek mainstems, and the upper portion of the unnamed tributary west of and parallel to NC-751. The mainstem of Third Fork Creek does not appear to be actively widening in most reaches surveyed though there may be concerns in some smaller confined areas (e.g., near Hamstead Court and the Third Fork Creek trail).

2.3.3 Stormwater Pollutant Stressors

Field crews assessed upland characteristics for each of 60 subwatersheds to observe potential sources of *stormwater pollutants*. Observed sources of sediment were typically found throughout the watershed with the exception of the highly pervious subwatersheds along the Third Fork Creek middle and lower mainstem and the newer commercial areas along Highway 54 in the southern part of the watershed (where recent development was required to use structural SCMs to meet TSS reduction requirements, as discussed in Section 4.3). Typical upland sources of sediment pollution are *gravel roadways*, *poorly vegetated lawn areas, new construction sites*, and *decaying pavement and parking areas*. Potential sources of nutrient loading from pervious surfaces in the watershed were primarily the Hope Valley Country Club Golf Course and *intensively managed lawns (*i.e., *with intensive fertilizer application)* in the more recently developed subwatersheds and areas of the upper watershed where extensive lawn maintenance is obvious. Other potential indicators are *pet and wildlife areas near ponds and streams*.

To assess pollutant loading throughout the entire watershed (even those areas that had not been walked), the City created a tool to simulate and quantify runoff and pollutant load for a variety of land development and stormwater management scenarios. The hydrologic and water quality benefits from stormwater management SCMs were simulated directly in the model, using a continuous simulation spanning more than a decade. The SWMM model was able to evaluate pollutant loading throughout the watershed under existing and future development conditions and correlate findings to field observations and GIS analysis discussed above. Through this assessment, the City team was able to identify areas of the City that are inflicting the highest stress on streams and water quality, and therefore should be the focus of management in this Plan. These are referred to as High-Priority Management Areas and are discussed in the following section. The assessment helped to identify strategies and practices that can be used in the High-Priority Management Areas to address their multiple stressors.

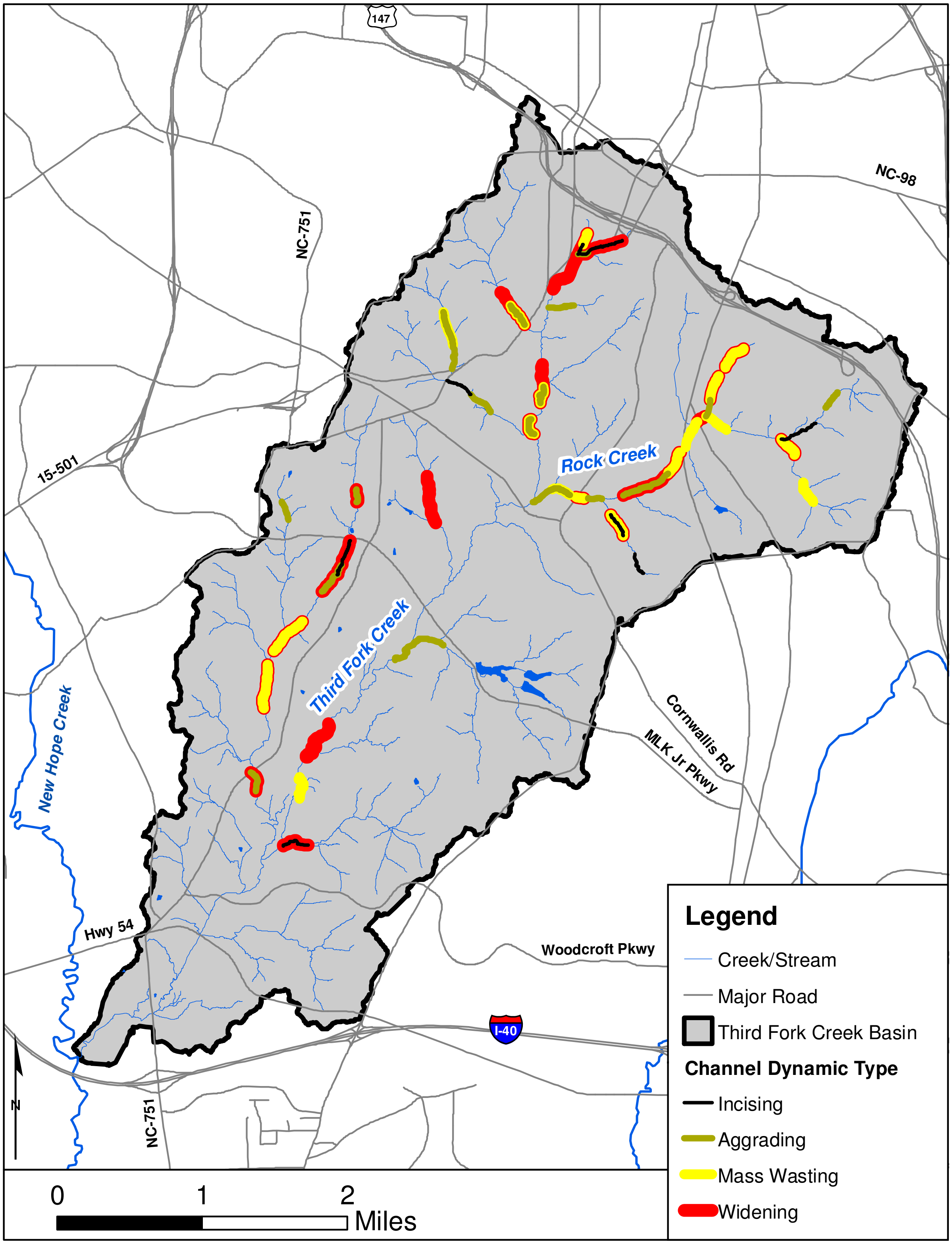

Figure 6. Observed Channel Dynamics in Surveyed Reaches

2.4 High-Priority Management Areas

To simplify the overall evaluation and provide more easily interpretable results linked to the management objectives, the shorter subset of the assessment indicators (aquatic habitat, channel stability, and simulated water quality) was applied to identify areas of the watershed most in need of management practices. The aquatic habitat and channel stability indicators provide measures for Objectives 1A through 2B, and the simulated water quality indicators provide measures for Objectives 3A-4B. All of these indicators are linked to objectives 5A-6D as explained in Section 3.

Scoring methods were developed that summarize the watershed impacts from multiple indicators. The pollutant loading indicators provide measurements of impacts of loading to a stream. Indicators like aquatic habitat provide measurements of instream impacts. Two separate scores were developed: (1) Subwatershed Loading Composite, and (2) Instream Composite. The 60 subwatersheds used in the SWMM model were scored by each individual indicator, and these individual scores were aggregated to calculate the two composite scores. The highest scores were assigned based on values that best represent achievement of the WMP goals and objectives.

A step-by-step process was used to identify management need areas that best address watershed impacts. The process resulted in assigning each subwatershed to one of the following management needs categories:

- Stream Corridor Restoration (SCR) Needs: the greatest need relating to instream channel and riparian area habitat impacts. Need SCRs that enhance or restore the stream channel or buffer area.
- Stormwater Control Measure (SCM) Needs: the greatest need relating to pollutant loading and hydrology impacts that would support stream restoration. Need SCMs that manage stormwater from existing impervious areas.
- SCR and SCM Needs: subwatersheds identified as having SCR and SCM needs.
- Fewer Needs

On the basis of the existing impacts and stressors in the watershed, high-priority management areas and practices were identified. The areas highlighted on Figure 7 are the highest priority areas for restoring stream corridors and reducing the effects from pollution and volume of stormwater runoff.

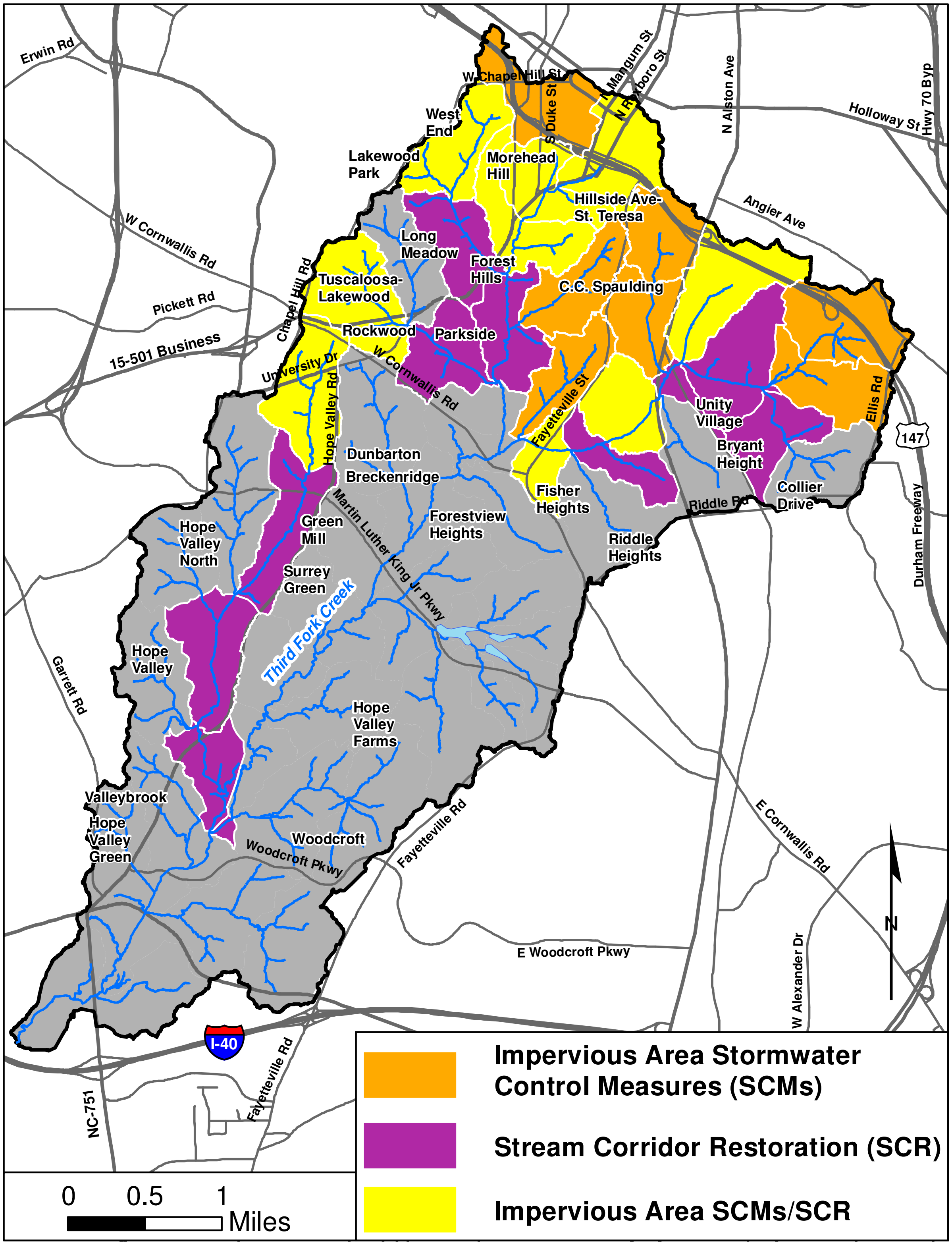

Figure 7. High-Priority Management Areas

3 Goals and Objectives

The Third Fork Creek WMP was built on explicitly defined goals and objectives. In this WMP, a goal is represented by a general statement about the desired condition or outcome of the watershed management or restoration strategies. Objectives are specific statements that define what must be true or what actions must be taken for the goals to be achieved. The objectives provide the foundation for watershed restoration and management decisions.

The goals and objectives developed for the Third Fork Creek WMP address stormwater impacts from existing development and are intended to protect critical lands in the watershed and help mitigate impacts from planned new development. With this in mind, five overarching goals were developed for the plan:

Goal 1. Restore and protect watershed functions, including water quality, aquatic habitat, and hydrology

Goal 2. Protect human health, safety, and property by reducing stormwater impacts

Goal 3. Support balanced, sustainable, and diverse land use and development in accordance with the City of Durham Comprehensive Plan and policies

Goal 4. Recruit and build partnerships and involve stakeholders in the protection and restoration of the watershed

Goal 5. Ensure compliance with federal and state regulatory mandates

Sixteen primary objectives were identified to support these goals (Table 4; Appendix E). The sixteen objectives were developed for the City to use in the Third Fork Creek WMP and in other watershed plans (Appendix D). Some of the primary objectives have “sub-objectives” reflecting specific issues, unique conditions, or important standards to meet in the Third Fork Creek watershed.

Some objectives are closely related to others. To highlight these relationships, they have been grouped into six categories: hydrology, habitat, stream water quality, drinking water quality, land use and development, and stewardship. Most of the objectives support multiple goals.

Many of the watershed plan objectives are difficult to measure directly. The relationship between stressors and effects on the objectives can be complex. To provide a basis for evaluating management strategies and decision making, a suite of *quantifiable* indicators was developed (Appendix F). These indicators represent measures that are relevant to the relationship between stressors and impacts, and measures that help evaluate the degree to which the goals and objectives are achieved. These indicators can be used to assess and develop plan recommendations and to track performance during plan implementation. For more information on the WMP indicators, see Section 6.4, Tracking and Evaluating Progress.

Table 4. Watershed Management Plan Objectives

Category 1. Hydrology
1A. Minimize impacts of stormwater runoff and erosion on stream hydrology to promote stable stream morphology and protect aquatic habitat. – New development shall produce no net increase in peak flow leaving the site when compared to predevelopment conditions for the 1-year, 24-hour storm. (Jordan Lake Rules, City Ordinance).
1B. Minimize flooding and erosion to protect property and human health and safety
Category 2. Habitat
2A. Provide for healthy aquatic habitat through protecting, restoring, and maintaining riparian buffers, wetlands, and in-stream habitat. – Protect remaining high-quality buffer areas. – Manage beaver ponds, as feasible, to provide the greatest overall benefit to the aquatic habitat and watershed residents. – Maintain and enhance hydrologic connectivity between floodplain and stream channels.
2B. Protect environmentally sensitive and critical lands that support protection or restoration of water quality or hydrology.
Category 3. Stream Water Quality
3A. Minimize effects on stream water quality from pollutants in stormwater runoff. – New development stormwater systems shall be designed to control and treat the runoff generated from all surfaces by one inch of rainfall. (Jordan Lake Rules).
3B. Detect and eliminate illicit discharges and sanitary sewer overflows to protect human health, enhance water quality and aquatic habitat.
3C. Address pollutants of concern for state approved TMDLs and water quality improvement plans. – Achieve a 35% reduction in TN watershed loading from existing sources (measured from 1997 to 2001 loading). (Jordan Lake TMDL and Rules). – Achieve a 5% reduction in TP watershed loading from existing sources (measured from 1997 to 2001 loading). (Jordan Lake TMDL and Rules). – Achieve a 53% reduction of TSS watershed loading from existing sources. (measured from 2000 to 2003 loading) (Third Fork Creek Turbidity TMDL). – New development shall not exceed 2.2 lb/ac/yr of nitrogen loading (Jordan Lake Rules). – New development shall not exceed 0.82 lb/ac/yr of phosphorus loading (Jordan Lake Rules).
Category 4. Drinking Water Quality
4A. Minimize effects on drinking water sources from pathogens, nutrients, and toxics in stormwater runoff.
4B. Ensure compliance with state water supply protection regulations for Jordan Lake.
Category 5. Land Use and Development
5A. Enforce site planning, design, construction and maintenance strategies to maintain or restore hydrology and water quality of the property.
5B. Identify cost effective strategies to minimize effects on the City, businesses, and residents.
5C. Identify restoration and protection strategies that complement the Durham City/County Comprehensive Plan and other policies and provide multiple benefits such as recreation and protection of critical lands. – Protect open space along the Third Fork Creek Trail and other trails in the watershed to protect water quality and provide contiguous habitat and recreation open space. – Enhance management and preservation of large privately owned open space (e.g., Woodcroft, Hope Valley Golf Course, and Hope Valley Farms) to enhance water quality protection.

Category 5. Land Use and Development (continued)
5D. Use the Watershed Restoration Program to inform updates to local policies and regulations.
Category 6. Stewardship
6A. Identify and recruit stakeholders and partners for protecting, maintaining, and restoring watersheds in the City of Durham.
6B. Identify and encourage the use of local, state, and federal assistance in implementing water quality improvements.
6C. Monitor, assess, and report progress toward protection and restoration.
6D. The City of Durham will lead by example in watershed stewardship through exemplary municipal operations and capital projects.

4 Existing Management Foundation

With regard to restoring and protecting Third Fork Creek, the City is not starting from scratch. Several local, state, and federal regulations affect activities in the watershed and form an existing management foundation to build on. Brief descriptions of the major regulatory requirements are provided to give context for management *improvements* recommended in this WMP. The measures listed in this section do not capture every program or activity that is part of the City's stormwater program; rather, they represent the more significant efforts and accomplishments by the City in the Third Fork Creek watershed.

4.1 MS4 NPDES Permit

Since 1994 Durham has been subject to the National Pollutant Discharge Elimination System (NPDES) Phase I permitting program under two requirements: construction activities that disturb five or more acres of land (one of 10 categories for industrial operations) and MS4 programs that serve populations of 100,000 or more. Durham is also subject to NPDES Phase II MS4 requirements as described in their 2007 permit. A new permit as part of the permit renewal process is anticipated in early 2013. Key components of Phase II requirements and representative recent program activities are listed in Sections 4.1.1 through 4.1.7.

4.1.1 Public Education and Outreach

- Established a Third Fork Creek website and Facebook page to provide regular updates on events, projects, and watershed planning.
- Installed dog waste stations in 25 Third Fork Creek watershed city parks.
- Created media campaign on buffer improvement and lawn care.
- Created and distributed outreach material to automotive facilities and power washers.
- Participated in biannual outreach workshops for landlords (property owners and managers).
- Offered teacher workshops on water quality (e.g., Earth Partnership for Schools).

4.1.2 Public Participation and Involvement

- Sponsored Creek Week stream cleanup in the spring and Big Sweep stream cleanup in the fall (collecting about 13,000 pounds (lb) of trash along streams in the City).
- Recruited participation for 20 City-sponsored rain gardens in Third Fork Creek neighborhoods, and used mayor's summer youth workers and volunteers to prepare and plant the rain gardens.
- Sponsored an Adopt-A-Stream program and held volunteer training.
- Promoted use of the City's Water Pollution Hotline.

4.1.3 Illicit Discharge Detection and Elimination

- Conducted inspections program to detect dry-weather flows, track, identify, and eliminate sources of contamination.
- Performed, in the most recent reporting year (October 2010 to September 2011), 263 initial investigations; conducted 70 follow-up investigations; issued 67 notices of violation; and eliminated 179 pollution sources.
- Maintained a stormwater system inventory, including major storm discharge outfalls.
- Trained municipal employees on illicit discharge detection.
- Established procedures to identify and eliminate failed septic systems and sanitary overflows.

4.1.4 Construction Site Runoff Controls

- Construction site runoff from privately funded development is controlled under provisions of a Unified Development Ordinance (UDO) adopted by the City and the County. As noted in more detail below, the ordinance applies to certain land disturbing activities anywhere in the County, including the City of Durham, and is enforced by the Durham County Sedimentation and Erosion Control officer.

4.1.5 Post-Construction Site Runoff Controls

- Adopted Stormwater Performance Standards for Development for Nitrogen and Phosphorus loading limits, TSS control, and peak flow mitigation.
- Required an operation and maintenance plan for each structural SCM.
- Required owners of structural SCMs to have each SCM inspected by a certified inspector annually and to submit annual maintenance inspection reports to the City.
- Conducted regular seminars for engineers, architects, developers, and SCM maintenance professionals during the year, and email notices of opportunities for stormwater management training topics offered by the state and local universities.

4.1.6 Pollution Prevention/Good Housekeeping for Municipal Operations

- Regenerative-air street sweepers collected 3,214 tons of debris from City streets, while hand-pickup along streets collected an additional 561 tons for FY 2011.
- The City's Stormwater Services industrial inspector inspected municipality-owned or operated NPDES permitted industrial and non-regulated facilities and priority non-regulated facilities.
- The City conducted annual maintenance of City-owned SCMs.

- The City's industrial inspector evaluated facilities and practices related to vehicle and equipment cleaning and identified heavy vehicle and equipment cleaning operations to minimize stormwater runoff.

4.1.7 Water Quality Recovery Plans and Monitoring

- The City's 2007 NPDES permit specifically addresses waters that the state has designated as impaired and that have subsequent approved TMDLs. For each TMDL, the permit requires the development of a Water Quality Recovery Plan (WQRP). A WQRP was prepared in 2005 for Third Fork Creek's turbidity TMDL and has been updated regularly. Its purpose is to provide a planning and implementation framework designed to reduce, to the maximum extent practicable, the levels of turbidity in Third Fork Creek from the City of Durham storm sewer system.
- As a part of the Phase II NPDES stormwater requirements and the WQRP, the City of Durham has been performing a combination of long- and short-term ambient monitoring and special studies in the Third Fork Creek watershed.

4.2 Erosion and Sedimentation Control

A locally delegated Erosion and Sedimentation Control Program is implemented for private development projects by Durham County. The program is required to meet minimum standards under state law. Codified in the UDO (Section 12.10; Durham City-County Planning, 2012), the County requires an erosion control plan for sites with disturbance greater than 20,000 square feet (since 1984). In addition, permits are required for land disturbance of more than 12,000 square feet. A plan or permit may be required for exempt areas of disturbance under certain conditions, including if off-site damage has occurred or the potential for off-site damage exists. Specific enhancements include traps and basins sized to handle the 25-year storm, skimmers required on sediment traps and basins, temporary ground cover within 7 to 14 days depending upon slope, and permanent ground cover within 7 days. The North Carolina Division of Land Quality enforces the state requirements on public projects.

4.3 Watershed Protection Overlay District

Watershed protection overlay districts are used in addition to base zoning to protect the quality of drinking water supplies and are associated with the state water supply watershed regulatory program (circa 1984). Development in this area has more constraints, and land use is maintained at a lower intensity than in other areas. The UDO has specific standards for watershed protection overlay districts that designate minimum lot size, impervious surface limits, and stormwater control requirements. It also has restrictions for wastewater treatment, sanitary sewer services, and storage of hazardous materials. Where the watershed protection overlay districts and zoning densities conflict, the more stringent requirements apply.

The primary watershed protection overlay district applicable to the Third Fork Creek watershed covers southern portions of the watershed: the Jordan Lake Protected Area. The area of the watershed covered in this portion is 2,491 acres and is classified by the City of Durham's UDO as a Falls/Jordan District B (F/J-B) overlay designation. For Jordan Lake, the F/J-B overlay is between 1 and 5 miles from the normal pool elevation (216 feet above mean sea level). As specified by the UDO (Sections 8.5 and 8.7), general requirements for the F/J-B overlay include a minimum lot size of 3 acres for Rural tier and 1 acre for Urban tier; impervious surface limits of 24 % for Low-Density and 70 percent for High-Density options; stream buffer widths of 100 feet for perennial streams and 50 feet for intermittent streams (100 feet for the High-Density Option); and stormwater control requirements for development intensity greater than the maximum authorized by the Low-Density Option to manage and treat the runoff from the first 1.0 inch of rainfall. Controls must be designed to remove 85 percent TSS. The watershed protection overlay district covers approximately 23 percent of the watershed (in the lower third area of the watershed).

4.4 Jordan Lake Nutrient Management Strategy

Jordan Lake, downstream of Third Fork Creek, was assessed as impaired by excessive nutrient loads resulting in North Carolina DWQ developing a TMDL that limits allowable nutrient loads to the lake. The *B. Everett Jordan Reservoir Water Supply Nutrient Strategy* is a comprehensive set of rules to reduce excess nutrient loading to the lake and implement the load reductions required by the Jordan Lake TMDL. The Jordan nutrient rules are unique among other previously implemented nutrient management strategies in North Carolina in that they address nutrient loading from existing development, contain stormwater requirements for all local governments in the watershed, require local implementation of buffer rules, contain a separate stormwater rule for state and federal entities, and include a separate rule outlining a trading framework to optimize options for cost-effective reductions. In addition to existing development, the other major pollutant sources targeted by the rules include agriculture, fertilizer application, wastewater discharges, and stormwater runoff from new development. The North Carolina General Assembly adopted the final set of rules under Session Laws 2009-216 and 2009-484. The Jordan Lake rules are separate from, but have similar components to, the more recently enacted nutrient management strategy and rules for Falls Lake.

Aspects of the final Jordan Lake rule requirements for new and existing development are described in sections 4.4.1 and 4.4.2.

4.4.1 New Development

- Nitrogen and phosphorus loads contributed by the proposed new development projects shall not exceed the unit-area mass loading rates applicable to that subwatershed for nitrogen and phosphorus, respectively, expressed in units of pounds per acre per year (2.2 and 0.82 in the Upper New Hope arm of Jordan Lake; Third Fork Creek drains to the Upper New Hope arm of Jordan Lake).
- Stormwater systems for nutrient reduction shall be designed to control and treat the runoff generated from all surfaces by one inch of rainfall. At a minimum, the new development shall not result in a net increase in peak flow leaving the site from pre-development conditions for the 1-year, 24-hour storm event.
- Developers shall have the option of offsetting part of their nitrogen and phosphorus loads by implementing or funding off-site management measures but can only have a maximum nitrogen loading rate of 4 pounds per acre per year for single-family, detached and duplex residential development and 8 pounds per acre per year for other development types.

4.4.2 Existing Development

Features of the law as described by DWQ are:

- Required local governments to submit Stage 1 adaptive management programs to DWQ by December 31, 2009. The program is aimed at controlling nutrient loading from existing development. The Stage 1 adaptive management program includes public education, mapping of major pollutant sources, and a program to identify opportunities for retrofits.
- Calls for lake impairment-triggered Stage 2 programs that would involve load-reducing measures for existing development. The need for Stage 2 programs would be determined by water quality monitoring results for Jordan Lake provided by DWQ starting in 2014 for the Upper New Hope Arm and 2017 for the Haw and Lower New Hope arms.
- Requires establishing a Nutrient Sensitive Waters Scientific Advisory Board that will be tasked with identifying management strategies to reduce nutrient loading from existing development; evaluating the feasibility, costs, and benefits of the strategies; developing an accounting system for assigning nutrient reduction credits for the strategies; and identifying the need for any improvements or refinements to modeling and other analytic tools used to evaluate water quality in nutrient-impaired waters and nutrient management strategies.

4.5 Other Stormwater and Riparian Buffer Requirements

The City of Durham has more stringent stormwater and riparian buffer requirements than the minimum in the state's Phase II and Water Supply Watershed programs. As specified in the City of Durham's UDO (Section 8.5; Durham City-County Planning), perennial and intermittent streams require a minimum 50-foot, natural, vegetated buffer (and up to 100 feet for intermittent streams or 150 feet for perennial streams in a Watershed Protection Overlay district). The UDO has an additional building setback from the buffer of 10 feet. Wetlands must be protected with a 25-foot buffer (excluding man-made ponds).

Beginning in 2009 (and revised in 2010 and 2012), the City applied additional TSS, nitrogen, and phosphorus export requirements to areas beyond the watershed protection overlay districts or Neuse Basin areas. The stormwater pollutant requirements apply to limited residential development disturbing 1 acre or more of land, and multi-family and other types of development disturbing 0.5 acre or more. Where the rules apply, developments must provide for an 85 percent reduction in TSS. Pursuant to the Jordan Lake Strategy and associated requirements, for the Upper New Hope arm of the Jordan Lake watershed in the City, nitrogen and phosphorus export from new development must be less than or equal to 2.2 and 0.82 pounds per acre per year (lb/ac/yr). If those rates cannot be achieved using on-site treatment, the 2012 ordinance provides a framework for making offset payments to a mitigation bank or purchasing nutrient credits to address the load deficit. On-site treatment must still generally be used to achieve a 40 percent reduction in nitrogen and a 40 percent reduction in phosphorus, or 30 percent reduction in the downtown area.

Alternative requirements for nitrogen and phosphorus control are provided for redevelopment sites. Projects in the downtown area that do not increase imperviousness prior to the baseline dates of the regulations do not need to provide additional nutrient reductions; developments that do not increase impervious area but are not in the downtown area will need to provide a 10 percent reduction in nitrogen and phosphorus onsite (or a 15 percent nutrient reduction offsite). Redevelopment projects that increase impervious area must achieve a 35 percent reduction in nitrogen and a 5 percent reduction in phosphorus as measured from the predevelopment load or meet the target unit loading.

The City has several important peak flow mitigation requirements:

- One-Year Storm. Development may not increase the post-development peak runoff rate from the 1-year storm over the predevelopment peak runoff rate. If the post-development peak runoff rate does increase, stormwater management facilities shall be provided such that there is no net increase.
- Two- and 10-Year Storms. Development that increases the peak runoff rate from either the 2-year or the 10-year storm may be required to install SCMs to address the impact, as determined in accordance with standards of the City's Engineering and Stormwater Divisions.
- Other Design Storms. Development that increases the peak runoff from other design storms, such as the 100-year storm, may be required to install SCMs to address the impact, as determined in accordance with standards of the City's Engineering and Stormwater Divisions.

5 Watershed Improvement Opportunities

SCM refers to constructed devices, natural vegetated areas, educational programs and actions to help reduce control, and clean stormwater before it washes into the creek. Typically, these measures are aimed at managing the water and constituent pollutants running off of *impervious* areas. Impervious areas are defined as surfaces impenetrable to water such as pavement (roads, sidewalks, driveways and parking lots) and rooftops. Therefore, SCMs comprise important means for improving watershed water quality. This WMP categorizes SCMs into two primary types, structural devices (engineered and constructed) and nonstructural practices (operational and procedural). Opportunities for structural and nonstructural SCMs in the Third Fork Creek watershed are described in Sections 5.1 and 5.2.

5.1 Structural SCMs

Much of the built upon land in the Third Fork Creek watershed contains older development constructed before the City started a stormwater management program requiring SCMs for development. To clean the water running off these untreated areas requires constructing new structural SCMs in areas of existing development. When new structural stormwater measures are constructed on built sites that have no or inadequate stormwater treatment, the process is referred to as *stormwater retrofitting*. It is much more expensive to add structural SCMs to existing property than it would be to include them in the original development design because it typically requires complex planning and design to avoid utility lines, demolition of existing built on surfaces, and purchasing land or easements where private property is involved. Because stormwater retrofitting is complex and expensive, the City wants to be strategic and implement structural SCM retrofits that are the most cost effective. An extensive screening and evaluation process was used to identify the best opportunities for structural SCMs in the Third Fork Creek watershed.

5.1.1 Initial Site Screening

Selecting new SCM sites in a watershed typically requires reasonable assumptions to focus the search. The City of Durham's property parcel layer includes approximately 18,600 individual parcels in the Third Fork Creek watershed. A GIS-based desktop screening was performed using a variety of data (including parcel information, aerial photography, sanitary and storm sewer locations, topographic and hydrographic data, and floodway locations) to narrow the focus to the land parcels with the best potential for success (see Appendix C). Screening emphasized three key criteria: (1) public property, (2) SCM sites near stream segments, and (3) existing ponds that could be retrofitted for effective stormwater management.

The initial screening produced 106 candidate sites. These sites were then further analyzed for 11 factors including details such as available area for SCM, off-site drainage, proximity to streams, soils, utility conflicts, upland pollutant loading and more (see details in Appendix C). After eliminating a subset of potential sites because of constructability limitations (e.g., extensive utility conflicts, lack of impervious contributing area, unsuitable topography), the number of potential SCM sites for all three site selection criteria was reduced to 55 sites for field validation.

5.1.2 Site Evaluation

Field investigations were conducted for the 55 potential new structural SCM sites identified in pre-field work plus 12 potential new sites identified while in the field (67 sites), along with the 46 existing structural SCMs throughout the Third Fork Creek watershed. The existing SCMs range from simple peak-flow management devices such as underground detention facilities to more complex water quality and quantity management practices such as bioretention basins and stormwater wetlands. The field investigations of the existing SCMs included observations of existing conditions and determination of suitability for retrofitting the structures for improved or expanded function.

5.1.2.1 Field Assessment of Existing SCMs

Existing SCMs in the Third Fork Creek watershed were observed to exhibit widely variable conditions. Older SCMs for which the City does not hold a maintenance and operations agreement from the owner were generally in very poor condition and exhibited little or no signs of regular maintenance. More recently constructed SCMs such as a site on the North Carolina Central University (NCCU) campus were well maintained and appeared to be functioning properly. Of the 46 existing SCMs in the Third Fork Creek watershed, six sites were recommended as feasible for a retrofit. Typical reasons for excluding an existing SCM for retrofit were:

- The SCM was recently constructed and exhibits proper function
- City of Durham Stormwater Services is currently working with the property owner to repair or upgrade the SCM
- There is no room for additional storage or extended detention
- The drainage area is too small to justify a retrofit

Most of the recommended retrofit options for the six selected SCM sites include converting existing dry detention basins into constructed wetlands by modifying the control structure and planting wetland vegetation. One wet pond was recommended for various retrofits that included adding a pretreatment forebay, wetland and littoral benches, and possibly an extended detention component. More details on the field assessment of existing SCMs are in Appendix C, BMP and Upland Assessment Report.

5.1.2.2 Field Assessment of Candidate New SCM Sites

The information collected for each potential new structural SCM site included:

- New SCM recommendations
- Site sketch
- Photos of proposed location for the SCM
- Utility conflicts
- Accessibility

Of the candidate 67 sites, 51 were determined to be feasible for new structural SCM implementation. Limited opportunities were identified for large-scale facilities such as new ponds and dry basins, largely a result of the developed nature of the watershed. Proposed types of new SCM retrofits are bioretention, constructed wetlands, wet ponds, porous concrete/sand filter systems, rainwater harvesting (plus subsequent landscape irrigation or other beneficial water use), tree boxes, level spreaders, and water quality retrofits to existing ponds. Bioretention was the most common SCM type recommended. The porous concrete and sand filters are recommended as a hybrid SCM because the Triassic Basin soils in the watershed limit soil infiltration (and thus nitrogen removal) and increase the cost of permeable concrete/paver systems. Installing sand filters as a secondary treatment component beneath permeable concrete provides additional nitrogen removal and reduces total construction cost by requiring less gravel base; it spreads mobilization cost between two SCM types. Figure 8 has a map showing the location of the most promising potential sites for retrofitting existing SCMs and for new structural SCMs (labeled with their Unique IDs).

5.2 Nonstructural SCMs

The City team reviewed existing, ongoing nonstructural management activities and highlighted those that are important for the Third Fork Creek watershed in helping to address nonpoint sources of pollutants of concern, and, where possible, to help meet multiple objectives of the WMP. As discussed in Section 4, these nonstructural, more programmatic SCMs form a large part of the City's existing management foundation in the watershed, a foundation that must be maintained in the future and, in some cases, strengthened. Section 5.2.1 discusses nonstructural SCMs that involve public education and outreach, and public participation and involvement. Other SCMs related to City programs such as illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, pollution prevention and good housekeeping for municipal operations, and monitoring are covered in Section 5.2.2 (City Programs and Codes).

5.2.1 Public Education, Participation and Involvement

Various techniques were used to assess opportunities for strengthening public education and participation efforts. First, the team evaluated ways to target existing efforts more effectively in High-Priority Management Areas (Figure 7). Second, nonstructural SCM program activities from other communities were screened in light of the City's ongoing efforts. Draft recommendations for enhancing existing or developing new nonstructural SCMs were shared with interested citizens during a public meeting; additional ideas generated from these public meetings were added to the list. Citizen participants voted on options in terms of level of importance. The team next assessed which opportunities could provide the most significant load reduction benefits for multiple parameters of concern and might meet multiple WMP objectives. On the basis of this assessment, high-priority recommended enhancements were identified for which the City plans to seek additional funding and partnerships.

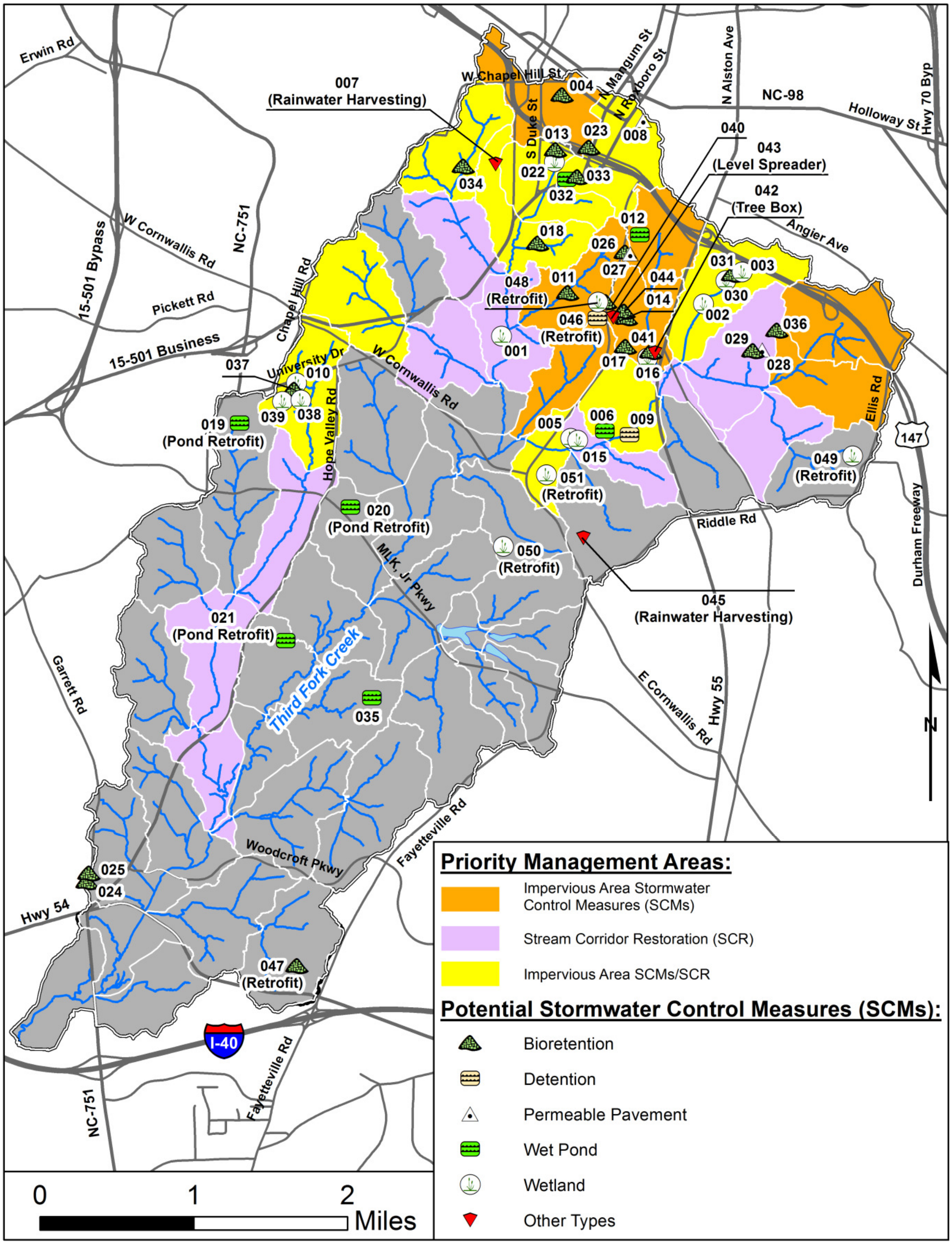

Figure 8. Potential Structural SCM Opportunities in the Third Fork Creek Watershed (labeled with their Unique Project ID)

The high-priority enhancements for public outreach, education, and participation in the Third Fork Creek restoration efforts are:

- Providing education and assistance to landowners regarding the benefits of stream buffers, no mow areas, and buffer replanting in High-Priority Management Area subwatersheds for stream restoration.
- Evaluating incentives for disconnecting impervious area.
- Targeting homeowner impervious area disconnection recruitment in the High-Priority Management Area subwatersheds for impervious area stormwater management.
- Prioritizing stream cleanup efforts in subwatersheds designated as High Priority for stream restoration or where field crews noted opportunities for enhanced stream cleanup efforts.
- Enhancing education and outreach with professional lawn and turf maintenance providers regarding proper use of fertilizer, the benefits of vegetated buffers, and the importance of revegetating bare, eroding areas in the turf or lawn.

A number of other potential enhancements to public education, outreach, and involvement were identified in the Implementation Strategy (Section 6) for future consideration.

During the course of field activities in the watershed, crews noted sources of observed pollutants and opportunities for nonstructural management actions. A set of recommended management actions was developed based on these observations. The most common management action is downspout gutter disconnection coupled with installation of on-lot rain gardens and fertilizer application training. The latter is suggested primarily for maintenance staff and other landscape professionals operating in the watershed; however, homeowners with large acreage sites could benefit from this training. In some subwatersheds, crews noted the need for parking and rooftop impervious area disconnection.

Field crews identified the need for enhanced golf course management in several subwatersheds. Golf course managers should be encouraged to consider the following practices to help mitigate pollutants in stormwater runoff:

- Leave a vegetated buffer between the mowed turfgrass and the edge of the stream bank.
- Educate maintenance staff regarding proper irrigation, pesticide use, and fertilization to reduce pollutant runoff.
- Assess the use of existing PVC drains observed running adjacent to fairways, some of which outlet to streams.
- Pursue Audubon Green Golf Course Certification or similar green certification.

Opportunities were noted for enhanced litter control and cleanup, including targeted stream cleanup, enforcement of trash enclosure requirements, catch basin cleaning, and street sweeping.

Table 5 lists the recommended nonstructural management actions developed by evaluating field notes and observations. The subwatershed IDs refer to the Third Fork Creek assessment subwatersheds on Figure 2. This list does not include every subwatershed in Third Fork Creek; it contains only subwatersheds with recommended nonstructural management actions. The City can use the information in the table to better guide program activities in the watershed. For example, public education campaigns on fertilizer management could be targeted to those subwatersheds identified in the table as exhibiting characteristics of high nutrient loading.

Table 5. Recommended Nonstructural Management Actions by Subwatershed

Subwatershed ID	Recommended action
101	Catch basin cleaning; Street sweeping; Improved pond maintenance
105	Golf course management
106	Golf course management
107	Golf course management
108	Potential rain garden sites
110	Education and outreach; Rain garden installation; Downspout disconnection
112	Rain garden installation
115	Rain garden installation
116	Rain garden installation
117	Disconnect impervious
118	Disconnect impervious
119	Disconnect impervious
120	Street sweeping; Downspout disconnection
121	Stream cleanup; Downspout disconnection
123	Education and outreach; Rain garden installation; Downspout disconnection
124	Education and outreach; Rain garden installation; Downspout disconnection
125	Street sweeping Downspout disconnection
126	Education and outreach; Rain garden installation
127	Clean inlets; Rain garden installation; Downspout disconnection
128	Rain garden installation; Downspout disconnection
130	Education and outreach
131	Education and outreach; Downspout disconnection
132	Rain garden installation
133	Maintain inlets at park; Education and outreach
136	Educate NCCU staff on proper fertilizer and chemical usage
138	Riparian area management (buffer replanting, *no mow* education)
139	Rain garden installation
144	Improve cemetery's erosion controls; Investigate recycling area
145	Downspout disconnection
146	Rain garden installation
147	Rain garden installation

Subwatershed ID	Recommended action
149	Rain garden installation
150	Revegetate pond banks; Sediment and erosion enforcement
153	Rain garden installation; Downspout disconnection
154	Rain garden installation; Downspout disconnection
155	Rain garden installation; Downspout disconnection
156	Rain garden installation; Downspout disconnection
157	Cisterns more suitable than rain gardens
158	Pet waste education; Potential *do not feed geese* education

5.2.2 City Programs and Codes

This section discusses recommended enhancements and changes to several existing program and code areas, including illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, pollution prevention and good housekeeping for municipal operations, and monitoring.

The review of existing City programs and codes built on the significant work accomplished in recent years. The City and County completed a Unified Development Ordinance (UDO). The City's Public Works Department completed a *Reference Guide for Development* (RGD) in 1998 and has been updating it periodically with key provisions for stormwater management, engineering, and transportation. In 2008, a Joint City-County Planning Committee established a steering committee to recommend environmental enhancements to the UDO. In its 2009 report, *Environmental Enhancements to the Unified Development Ordinance,* the steering committee reported its recommendations in four key areas: sedimentation and erosion control, water quality and stream buffers, site preparation, and tree protection. Many of these recommendations have since been implemented. As a part of developing the Ellerbe Creek WMIP, the City completed a report, *Better Site Design: A Review of Low Impact Development Practices and Recommendations for Implementation*, and the City is moving forward with many recommendations in it. The City is in the process of revising a number of elements of the RGD.

As a part of developing this WMP, the City team reviewed the documents referenced above and ongoing programs to identify opportunities for strengthening watershed restoration efforts. Different techniques were used to assess opportunities, including targeting existing efforts more effectively in High-Priority Management Areas, screening nonstructural SCM program activities from other communities, interviewing City Stormwater Services Division program staff and private SCM maintenance vendors, and soliciting input from interested citizens. From the menu of options identified, the City team assessed which actions could provide the most significant load reduction benefits for multiple parameters of concern and where program enhancements could meet multiple WMP objectives. On the basis of this assessment, high-priority recommended enhancements were identified in the areas discussed below. For more detailed information, see Appendix L, Code and Ordinance Review and Appendix M, Maintenance Program Review.

5.2.2.1 Reference Guide for Development Revisions for Implementing LID SCMs in Triassic Basin Soils

An evaluation was done to answer the questions: Which LID techniques work in Triassic Basin soils? How should they be designed with the City's inherent Triassic Basin soil constraints? How should the RGD be modified with respect to implementing LID in the Triassic Basin? The following priority actions were identified to improve LID implementation:

- Develop and pursue approval of Triassic Basin specific standards for SCMs whose volumetric water loss is dependent on soil infiltration capacity. Such standards will likely vary from DWQ's generic standards and will provide for optimized performance under local conditions.
- Make changes to the City's permeable pavement design standards to better suit Durham's hydrologic and soil conditions after the new state permeable pavement chapter is added to the state BMP manual.
- Finalize SCM design standards regarding allowing bioretention with internal water storage in C and D soils, as long as IWS is implemented in such a way that the aerobic portion of the media can be ensured to be at least 2 feet deep (i.e., place underdrain and media bottom at a lower elevation than typical resulting in a deeper IWS top elevation).
- Revise RGD to require use of the *raked method* for constructing the bioretention bottom surface.

5.2.2.2 UDO and RGD Revisions for Street Design

The team evaluated additional modifications needed to better incorporate LID techniques into street design. Two priority enhancements were identified.

- Consider alternative reduced street widths, such as 20 feet for Residential Limited and Residential Street and 26 feet for Residential Local Street (with on-street parking, one lane).
- Revise street cross-sections, or provide cross-section alternatives, to include water quality treatment devices.

5.2.2.3 RGD Revisions for Cistern Configuration and Use

The use of rainwater harvesting cisterns has grown significantly in the North Carolina Piedmont in recent years. One of the primary drivers for the growth of this practice has been the prevalence of drought and the resultant reduction in potable water supply. These devices are able to reduce stormwater runoff and pollutants, thereby helping to meet stormwater management requirements. In the last several years, DWQ approved rainwater harvesting systems in the BMP manual as a SCM with a related volume reduction credit for use in meeting state stormwater program permit requirements. Depending on the intended end use of stored water cisterns, the City could rely on the capacity of in situ soils to infiltrate and reduce runoff volumes. Cistern systems differ from other SCMs in (1) the timing of runoff *application,* and (2) the overall loading rate relative to potential infiltration and evapotranspiration. As a result, cistern systems are not as reliant on soil conditions and could help meet larger regional water resources and City stormwater management objectives.

Described below are a number of specific recommendations for revisions of the RGD to better support and encourage the use of cisterns in the City.

- Provide additional language requiring the implementation of an automatic system for isolating collected rainwater from potable backup supply. Such systems typically rely on a system of float switches in the cistern storage container that route potable water into the cistern if the cistern is completely dry and maintain a minimal volume of water in the cistern to ensure that demand requirements are met. Such systems ensure that stored rainwater is used when available and potable water used only when stored rainwater has been exhausted.
- Existing text indicates that cisterns should be *opened* during non-demand periods in such a way that drawdown of stored runoff occurs over a 12- to 24-hour period. Cistern installations often consist of subsurface storage vessels, which might not have a drawdown capacity. Revise the text to allow pumped drawdown of stored cistern volume during winter shutdown as follows: "…storage tanks should be opened *or an automatic pumping system installed* so that captured flows (at capacity) drawdown….."
- Revise the text to clarify that cistern drawdown volume need not be included in the BMP sizing calculations because the drawdown flow rate is likely to occur at the same or lower rate as the BMP outflow rate. Also consider discouraging routing of cistern drawdown volume to BMPs with sensitive vegetation conditions to prevent causing excessively wet conditions that could harm vegetation.
- Develop standard cistern configuration sketches, detail drawings and or specifications for residential installation (likely the most common potential retrofit). The developed guidance information would assist new and retrofit designers in quickly incorporating cisterns into the urban landscape.

5.2.2.4 Pollution Prevention and SCM Maintenance for Municipal Operations

Once SCMs are constructed, stormwater controls must be inspected, maintained, repaired, and replaced over the long term to ensure proper performance and good working conditions. Pollution prevention, inspections, maintenance, and other good housekeeping practices are critical to preserving public and private investments in stormwater infrastructure. The City team's review of existing procedures revealed several important potential enhancements:

- Develop an inspection and maintenance program for SCMs on City property, including developing strategies for SCM maintenance, and a Memorandum of Understanding (MOU) between the Stormwater Services Division and the property manager that clearly spells out and delineates maintenance responsibilities.
- Incorporate a basic level of service statement into the SCM maintenance program documents. A basic level of service statement is as follows: *Each stormwater SCM facility in the City of Durham, whether on public or private property, shall be maintained in a manner that ensures the SCM meets its basic functional requirements at all times including structural stability, pollutant removal, hydraulic function, and erosion control.*

- Implement a pilot program to assess catch basin materials and cleaning schedule. The pilot program would assess catch basin materials (e.g., trash, yard waste, sediment), create data records of catch basin constituents and build up levels in certain areas (e.g., metals, oil and grease, nutrients, and bacteria), and evaluate optimization of cleaning according to the materials removed. Such a program would help to focus the level of effort on the highest priority loading areas and pollutant sources. The materials removed could be evaluated for pollutant concentrations, total volumes of materials removed, and particle sizes. On the basis of this pilot program, a catch basin cleaning schedule could be developed to optimize frequency of cleaning during wet and dry periods according to water quality, flood control, and aesthetics.

A number of other potential enhancements were identified for ongoing pollution prevention, maintenance, inspections, and good housekeeping activities. These opportunities are listed in the Implementation Strategy for future consideration as resources allow.

5.3 Stream Channel and Riparian Buffer Restoration

In addition to structural and nonstructural SCM opportunities, the field assessment identified a wide range of stream channel and riparian buffer impacts in need of management. A number of management opportunities throughout Third Fork Creek have been identified for restoring affected stream channel and riparian areas. Four levels of stream restoration are included with recommendations, defined in Sections 5.3.1 through 5.3.4.

5.3.1 Comprehensive Stream Restoration

This category recommends that unstable, altered, or degraded stream corridor (including adjacent riparian buffers and floodplain) be reestablished to its natural stable condition. This would include restoring the reach to stable physical dimensions (i.e., dimension, pattern, and profile), and restoring biological and water quality functions. This typically includes a change in channel location or improved sinuosity, reestablishing habitat conditions generally through stream channel longitudinal slope and streambank changes, and could include streambed changes. This is the most intensive and resource demanding management activity.

Six stream reaches in the Third Fork Creek watershed have been recommended for comprehensive restoration—5,475 feet of stream (see Figure 9). These reaches have been identified as unstable or degraded to the point where they are contributing to water quality problems or represent a potential risk in loss of property if not addressed.

5.3.2 Enhancement Level 1

This category includes improvements to the stream channel and riparian zone to restore channel stability, water quality and stream ecology. Channel dimension (streambanks) and profile (streambed's longitudinal slope) are typically addressed at this level; however, restoring a more natural channel pattern to the stream through channel relocation is typically not feasible due to cost, space limitations in a built up environment, and other constraints. Depending on design, this category could also include other practices that provide improved water quality and ecological benefits.

There are 13 stream reaches—approximately 11,000 feet (2.1 miles)—that are recommended for Enhancement Level 1 restoration on the basis of current stream conditions (see Figure 9). These reaches might require stream channel and riparian area restoration to improve channel stability, water quality, and stream ecology using both dimension and profile improvements.

5.3.3 Enhancement Level 2

This category includes activities that augment channel stability, water quality and stream ecology but do not restore either dimension or profile. Depending on design, this category can also include other practices that provide improved water quality and ecological benefits.

Twenty-four stream reaches are recommended for Enhancement Level 2 restoration in the Third Fork Creek watershed—approximately 20,150 feet (4.0 miles) (see Figure 9). These reaches need channel stabilization projects that include profile changes or, in select locations, cross-sectional improvements.

5.3.4 Streambank Stabilization

Streambank stabilization is the in-place stabilization of an eroding stream bank. Stabilization techniques include (1) using materials like root wads and log crib structures, (2) sloping back steep streambanks, and (3) revegetating the riparian zone.

Ten reaches in the Third Fork Creek watershed are recommended for bank stabilization—approximately 8,050 feet (1.5 miles) (see Figure 9). These reaches have been identified as having slumping or eroding channel banks. Stabilizing the banks using natural materials (such as root wads and log structures) is recommended. Some areas could be improved by simple slope changes and bank revegetation to prevent further degradation. For example, the stretch of reaches that are categorized as needing bank stabilization at the Historic Hope Valley Golf Course could be managed with streambank revegetation and stabilization coupled with minor changes in the landscape management surrounding the stream channel such as a setback width that should remain unmowed. This type of management is effective for stabilization projects and is typically a low cost management strategy.

5.3.5 Buffer Restoration

Riparian buffer restoration refers to any activities in the area within at least 50 feet of the active stream channel that would restore the riparian area to a more natural, vegetated state. Restoration is often a combination of tree planting, invasive plant species control and removal, or removal of human infrastructure (e.g., fences, buildings, roads, if feasible). Of the 53 stream management reaches, 31 are recommended for buffer restoration (see Figure 9).

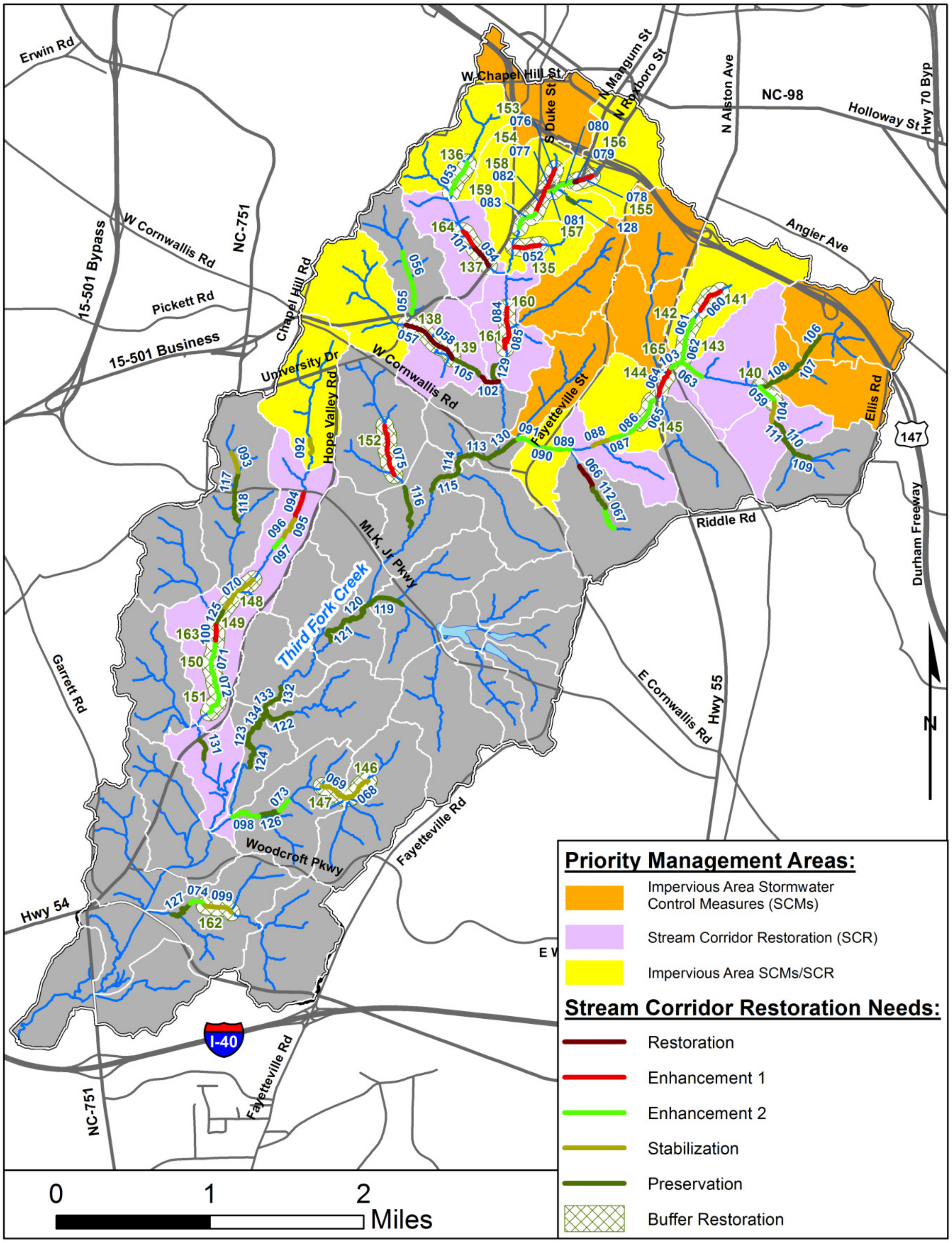

Figure 9. Stream Channel and Buffer Restoration Opportunities in Third Fork Creek Watershed (labeled with their Unique Project ID)

5.4 Riparian Area Management

In addition to the restoration opportunities for riparian buffer areas described in WMP section 5.3.5, additional programmatic protection measures have been established. Currently, the City of Durham has a Riparian Area Management Plans (RAMP) to address maintenance practices in riparian buffers on City-owned property, utility easements, and greenway corridors in two watersheds—Ellerbe Creek and Third Fork Creek. A RAMP for Northeast Creek and Crooked Creek is under development. The RAMP was first developed for the Ellerbe Creek watershed and has been updated for Third Fork Creek through this watershed management planning process (see Appendix I, Riparian Area Management Plan Update). Management, design, and maintenance personnel should follow the RAMP when planning and designing new infrastructure and facilities, improving existing facilities, or performing maintenance on water and sanitary sewer lines and easements, parks and recreation facilities, stormwater and flood-control projects, roads, and public works facilities. The RAMP recommendations are written to apply to any public lands and publicly maintained land where:

- Riparian buffers do not exist.
- Buffer rules do not apply.
- Preexisting development and ongoing maintenance activities are exempt from current riparian buffer regulations.
- Important riparian lands lie beyond the regulatory buffer.

Key provisions of the RAMP are maintenance (e.g., protecting existing riparian buffers, converting mowing practices and techniques), riparian buffer restoration, design structure maintenance, pollutant avoidance, and public education and involvement. The main recommended program enhancements are folded into the Non-Structural SCM Public Education and Involvement and the City Program and Codes action items.

5.5 Critical Areas Protection

As part of this plan’s objective to support protection of existing resources, the City team worked with the consultant to (1) identify critical land areas where protection of natural features will be important, and (2) develop recommendations for the protection of land critical to maintaining existing watershed functions (see Appendix H). This Critical Area Protection Plan or CAPP addresses the unique objectives in the Third Fork Creek watershed that relate to achieving water quality protection through land preservation.

Protecting undeveloped areas along stream riparian corridors—particularly undisturbed, naturally vegetated land—can help maintain nutrient assimilation, flood retention, and other water quality functions of stream ecosystems. Preserving riparian area provides benefits by protecting the land from disturbance and by treating runoff from upland areas or flood water from adjacent streams. Protecting upland areas can provide significant water quality benefits by preventing future disturbance that would cause increased pollutant loading and stormwater flow.

Most land in the Third Fork Creek watershed is developed or disturbed, including significant sections of riparian areas. Despite these conditions, undisturbed forested areas remain in the watershed, and portions of stream corridors remain forested. Several areas of undeveloped land are owned by public entities and used for recreation, open space, or other purposes. Private entities own some of the undisturbed land, which, if preserved, would contribute to protecting the existing water quality functions of the watershed. More than 4,000 parcels were initially reviewed for protection potential; of those, 212 were prioritized for consideration. Critical land sites were identified on the basis of (1) ranking highly in terms of providing watershed water quality benefits, (2) site-specific benefits, and (3) cost-effectiveness with respect to pollution reduction (see Appendix H, Critical Area Protection Plan). A parcel was categorized as a *Keystone Property* if it was near a large protected area. One hundred twenty-three parcels —580 acres— were classified as Keystone Properties. Smaller, high-quality parcels in the watershed's more urbanized areas were categorized as *Urban Gems*. Eighty-nine parcels encompassing 63 acres were classified as Urban Gems. Figure 10 shows the location of these identified priority parcels as Special Natural Areas to Protect in the Third Fork Creek watershed (labeled with their Unique IDs).

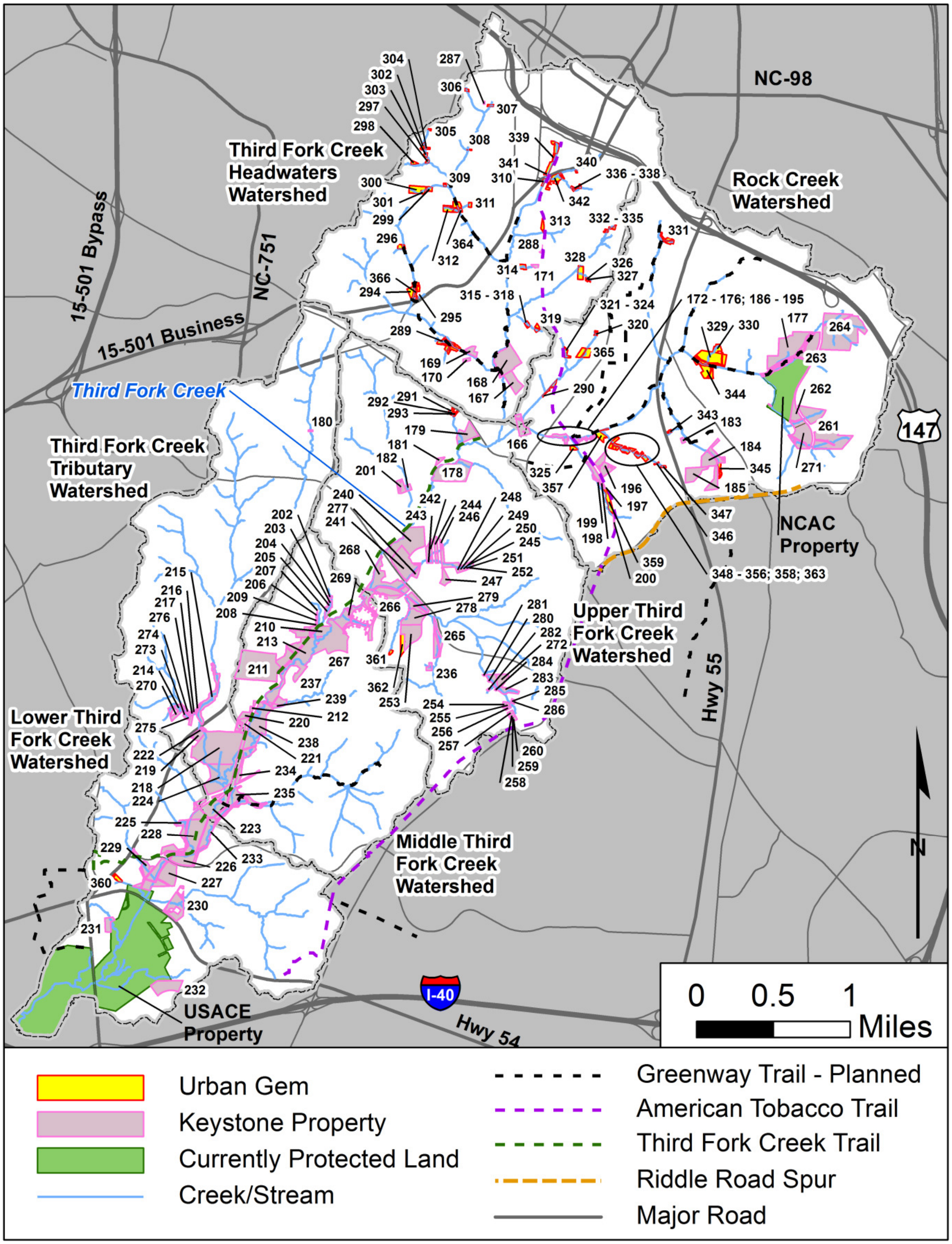

Figure 10. Special Natural Areas to Protect (labeled with their Unique Project ID)

5.6 High-Priority SCM Sites for Implementation

Although this WMP identifies many structural and nonstructural opportunities for management, practical considerations regarding available funds and City staff time mean that the City will have to prioritize implementation. This WMP prioritized structural stormwater SCMs and stream corridor restoration opportunities, building on the methods used for the Ellerbe Creek WMIP. Adaptations were incorporated based on issues specific to the Third Fork Creek watershed, available data, and analysis methods (see Appendix G). The method used in this WMP applied a score to identified opportunities based on six categories tied to the goals and objectives described in Section 3: water quality treatment (pollutant load reduction), habitat and biological integrity, streambank and channel protection, community enhancement (e.g., property protection, property owner and neighborhood acceptance, and public education), implementation feasibility (property ownership, city program compatibility, and accessibility), and public safety / public property considerations. A weighted total score was determined for each SCM, stream restoration, and buffer restoration opportunity to facilitate ranking and prioritization. This information was combined with the High Priority Management Areas shown in Figure 7 to select the best projects. The top 15 sites for new SCMs, top 3 sites for retrofit of existing SCMs, top 15 sites for stream restoration and enhancement, and top 15 sites for buffer restoration are listed in Table 6 and their locations are shown on Figure 11.

The highest priority opportunities for land to be protected in the Third Fork Creek watershed are also displayed in Table 6 and on Figure 11. The top 15 keystone sites and top 15 urban gem sites were selected on the basis of the CAPP priority ranking.

Table 6. Recommended High Priority Sites and Practices

Map ID[1]	Unique ID[2]	Type	Description	20-Year Life Cycle Cost
Stormwater Control Measures – New				**Total: $3,581,396**
1	005	Wetland	Just east of the Utah St. and Fayetteville St. intersection. Legacy project ID 130.	$350,902
2	010	Wetland	Just east of the University Drive entrance to Hope Valley Elementary School. Legacy project ID 160.	$194,421
3	006	Wet Pond	Western edge of the playing fields of Shepard Middle School near the corner of Elmira Avenue and Dakota Street. Legacy project ID 131.	$363,381
4	004	Bioretention	Median areas within the new City of Durham bus terminal adjacent to impervious areas of bus loading and unloading zones. Legacy project ID 118.	$339,531
5	036	Bioretention	Behind the Phail Wynn, Jr. Student Services Center on Durham Technical Community College, Durham Campus between E Lawson Street and Cooper Street. Legacy project ID A_n_2.	$171,483
6	018	Bioretention	At the eastern edge of Forest Hills Park just downstream and west of the American Tobacco Trail. Legacy project ID 1722.	$190,071
7	039	Wetland	Southwest corner of Hope Valley Elementary School off Dixon Road. Legacy project ID B_n_3.	$185,212
8	030	Wetland	Downhill and southeast of Burton Elementary School located at the corner of Mathison Street and Lakeland Street. Legacy project ID 164a.	$155,994
9	032	Wet Pond	At the northwest corner of Blackwell Street and W. Lakewood Avenue near Forest Hill Heights. Legacy project ID 789a.	$173,977
10	012	Wet Pond	Northwest of WG Pearson Magnet Middle School at the intersection of E. Umstead Street and Merrick Street. Legacy project ID 165.	$217,646
11	007	Rainwater Harvesting	Morehead Elementary School between W. Cobb Street and W. Lakewood Avenue. Legacy project ID 141.	$221,711
12	013	Bioretention	Just south of Durham Freeway (Highway 147) near the Old Tobacco Campus. Behind the array of satellite dishes at the corner of W. Morehead Avenue and Blackwell Street. Legacy project ID 169.	$379,662
13	015	Wetland	A community park that consists of tennis courts, basketball courts, a playground area and associated parking and other facilities. Legacy project ID 182.	$276,547

Map ID[1]	Unique ID[2]	Type	Description	20-Year Life Cycle Cost
14	017	Bioretention	On NC Central University campus just south of Nelson Street across the street from three older, converted residential buildings. Legacy project ID 204.	$192,856
15	038	Wetland	Southeast corner of Hope Valley Elementary School. Legacy project ID B_n_2.	$168,002
Stormwater Control Measures – Retrofit				**Total: $316,494**
1	051	Wetland Retrofit	Cleared area off of the entrance drive to W.G. Pearson Elementary School near the intersection of Fayetteville Road and E. Cornwallis Road. Legacy project ID 452.	$119,169
2	048	Wetland Retrofit	Open space courtyard area on NC Central University Campus near the corner of E. Lawson Street and Concord Street. Legacy project ID 294.	$96,921
3	046	Detention Retrofit	Southern side of NC Central University Campus Building between building and Formosa Avenue near Concord Street. Legacy project ID 70.	$100,404
Stream Corridor Restoration				**Total: $9,857,160**
1	100	Enhancement Level 1 Stream Restoration	Unnamed tributary of Third Fork Creek flowing through Hope Valley Golf Course from below Surrey Road down to next project. Legacy project ID 233.	$356,929
2	071	Enhancement Level 2 Stream Restoration	Unnamed tributary of Third Fork Creek flowing through Hope Valley Golf Course from above Dover Road approximately 1,700 feet down to the Dover Road crossing. Legacy project ID 142.	$820,378
3	101	Enhancement Level 1 Stream Restoration	Unnamed tributary to Third Fork Creek on the western edge of Forest Hills Park downstream of W. Forest Hills Blvd. for approximately 600 feet. Legacy project ID 234.	$530,085
4	054	Comprehensive Stream Restoration	Unnamed tributary to Third Fork Creek on the western edge of Forest Hills Park upstream of 15-501 Business (University Blvd.) for approximately 1,550 feet. Legacy project ID 103.	$1,099,702
5	085	Enhancement Level 1 Stream Restoration	Third Fork Creek just downstream of S. Roxboro Road down to the western terminus of Red Oak Avenue. Legacy project ID 211.	$636,003
6	084	Enhancement Level 1 Stream Restoration	Third Fork Creek just downstream of the existing stream restoration project to S. Roxboro Road. Legacy project ID 210.	$676,783

Map ID[1]	Unique ID[2]	Type	Description	20-Year Life Cycle Cost
7	086	Enhancement Level 2 Stream Restoration	Rock Creek from near the western end of Corona Street to near the western end of Chalmers Street for approximately 450 feet. Legacy project ID 213.	$314,556
8	070	Stream Bank Stabilization	Unnamed tributary of Third Fork Creek flowing through Hope Valley Golf Course from Devon Road to Surrey Road. Legacy project ID 140.	$903,066
9	061	Enhancement Level 2 Stream Restoration	Unnamed tributary of Rock Creek running from E. Lawson Street just west of S. Alston Ave (Highway 55) under Dayton Street ending at Truman Street. Legacy project ID 118.	$696,503
10	064	Enhancement Level 1 Stream Restoration	Rock Creek flowing down from S. Alston Avenue to Apex Highway/Highway 55. Legacy project ID 121.	$978,252
11	090	Enhancement Level 2 Stream Restoration	Rock Creek from approximately 300 feet upstream (east) of Fayetteville Street to its crossing under Fayetteville Street. Legacy project ID 217.	$265,673
12	059	Enhancement Level 2 Stream Restoration	Unnamed tributary of Rock Creek running parallel behind the houses north of Hearthside Street near Welch Place. Legacy project ID 116.	$620,672
13	087	Enhancement Level 2 Stream Restoration	Rock Creek from near the western end of Chalmers Street for approximately 875 feet to Elmira Avenue. Legacy project ID 214.	$592,861
14	080	Enhancement Level 2 Stream Restoration	Third Fork Creek headwaters flowing parallel to 15-501 Business (W. Lakewood Avenue) between 15-501 Business and Hillside Avenue flowing under South Street. Legacy project ID 206.	$517,591
15	098	Enhancement Level 2 Stream Restoration	Unnamed tributary to Third Fork Creek that flows into Third Fork Creek just downstream (south) of S. Roxboro Street in Hope Valley Farms subdivision. Legacy project ID 231.	$848,106
Buffer Restoration				**Total: $3,363,811**
1	137	Buffer Restoration	Unnamed tributary to Third Fork Creek on the western edge of Forest Hills Park upstream of 15-501 Business (University Drive) for approximately 1,550 feet. Legacy project ID 103.	$183,259
2	142	Buffer Restoration	Unnamed tributary of Rock Creek running from E. Lawson Street just west of S. Alston Avenue (Highway 55) under Dayton Street ending at Truman Street. Legacy project ID 118.	$227,971

Map ID[1]	Unique ID[2]	Type	Description	20-Year Life Cycle Cost
3	144	Buffer Restoration	Rock Creek flowing down from S. Alston Avenue to Apex Highway (Highway 55). Legacy project ID 121.	$275,418
4	141	Buffer Restoration	Unnamed tributary to Rock Creek east of S. Alston Avenue (Highway 55) on northern edge of park (park name unknown) flowing for approximately 1,020 feet parallel to Sima Avenue and continuing under Ridgeway Avenue. Legacy project ID 117.	$162,322
5	135	Buffer Restoration	Unnamed tributary to Third Fork Creek on the eastern edge of Forest Hills Park downstream of E. Forest Hills Blvd. Legacy project ID 101p).	$175,850
6	164	Buffer Restoration	Unnamed tributary to Third Fork Creek on the western edge of Forest Hills Park downstream of W. Forest Hills Blvd. Legacy project ID 234.	$139,395
7	158	Buffer Restoration	Third Fork Creek downstream from the intersection of W. Lakewood Avenue and 15-501 Business (University Drive). Legacy project ID 208.	$429,245
8	155	Buffer Restoration	Unnamed tributary to Third Fork Creek downstream of the intersection of S. Roxboro Street and 15-501 Business (Lakewood Avenue). Legacy project ID 204.	$145,885
9	159	Buffer Restoration	Third Fork Creek on the northern edge of Forest Hills Park running under W. Enterprise Street. Legacy project ID 209.	$535,421
10	136	Buffer Restoration	Unnamed tributary to Third Fork Creek running through Lyon Park and Center from the north end of the park to W. Lakewood Avenue east of Kent Street. Legacy project ID 102.	$221,594
11	156	Buffer Restoration	Unnamed tributary to Third Fork Creek running parallel to and on the south side of 15-501 Business (W. Lakewood Avenue). Legacy project ID 205.	$113,371
12	145	Buffer Restoration	Rock Creek flowing downstream of the intersection of Dakota Street and Highway 55 for approximately 900 feet and west of Highway 55. Legacy project ID 122.	$222,469
13	139	Buffer Restoration	Unnamed tributary to Third Fork Creek flowing parallel to and on the north side of W. Cornwallis Road between University Drive and S. Roxboro Street downstream from Whitley Drive. Legacy project ID 107.	$205,020
14	153	Buffer Restoration	Third Fork Creek flowing downstream of Cobb Street toward 15-501 Business (W. Lakewood Avenue). Legacy project ID 201.	$173,594
15	154	Buffer Restoration	Third Fork Creek flowing from the downstream end of Buffer Restoration-14 for approximately 300 feet to 15-501 Business/W. Lakewood Avenue. Legacy project ID 202.	$152,997

Map ID[1]	Unique ID[2]	Type	Description	20-Year Life Cycle Cost
Keystone Properties[3]				**Total: $11,714,904**
1	178	Keystone Property	Parcel ID #122367 along the eastern banks of Third Fork Creek between Barnhill Street (to the north) and Springdale Drive (to the south and east).	$392,258
2	268	Keystone Property	Parcel ID #196541 on both sides of Third Fork Creek spanning from the corner of S. Roxboro Street and Martin Luther King, Jr. Blvd. west to the Creek.	$30,352
3	240	Keystone Property	Parcel ID #146335 along the eastern banks of Third Fork Creek between the new Walmart located at S. Roxboro Street and Martin Luther King, Jr. Blvd. (to the east) and Durham County's Maintenance facility accessed off of Martin Luther King, Jr. Blvd. (to the west).	$293,965
4	218	Keystone Property	Parcel ID #135307 just downstream of Historic Hope Valley south of Willow Bridge Drive. A sanitary sewer easement runs through this parcel.	$2,444,232
5	237	Keystone Property	Parcel ID #145481 along the eastern banks of Third Fork Creek between Carlton Crossing Drive (to the east) and Oriole Drive (to the west).	$717,899
6	210	Keystone Property	Parcel ID #135103 along the western banks of Third Fork Creek east of Berwick Court just north of Keystone Unique ID 213.	$533,671
7	213	Keystone Property	Parcel ID #135177 along the western banks of Third Fork Creek east of Burnley Court just south of Keystone Unique ID 210.	$1,146,852
8	224	Keystone Property	Parcel ID #135498 on both sides of Third Fork Creek adjacent to and just north (upstream) of S. Roxboro Street in Hope Valley Farms subdivision.	$1,013,416
9	166	Keystone Property	Parcel ID #107193 located near the Faith Assembly Christian Academy off of Fayetteville Road between the southern terminus of Jubilee Lane and the northern terminus of Atlantic Street.	$63,411
10	227	Keystone Property	Parcel ID #135691 on both sides of Third Fork Creek just downstream of W. Woodcroft Parkway. This area includes the play fields just west of Woodcroft Swim and Tennis Club and forested lands behind Woodcroft Shopping Center.	$1,276,885
11	267	Keystone Property	Parcel ID #196540 just east of Keystone Unique IDs 210 and 213 and west of Brenmar Lane and Cherry Blossom Circle.	$386,609
12	238	Keystone Property	Parcel ID #145491 along the eastern banks of Third Fork Creek between Bridgewood Drive (to the east) and Willow Bridge Drive (to the west).	$819,561

Map ID[1]	Unique ID[2]	Type	Description	20-Year Life Cycle Cost
13	223	Keystone Property	Parcel ID #135497 on both sides of Third Fork Creek adjacent to and just south (downstream) of S. Roxboro Street in Hope Valley Farms subdivision.	$1,214,678
14	269	Keystone Property	Parcel ID #198505 just east of Keystone Unique ID 267 and west of S. Roxboro Street, north of Brenmar Lane.	$1,144,097
15	262	Keystone Property	Parcel ID #156681 in the headwaters of Rock Creek to the west of S. Briggs Avenue at the southern end of Person Street.	$237,018
Urban Gems[3]				**Total: $ 901,950**
1	359	Urban Gem	Parcel ID #133429 just west of the American Tobacco Trail and east of Hillside High School.	$20,725
2	357	Urban Gem	Parcel ID #133266 on the eastern side of Rock Creek just southwest of Elmira Avenue.	$160,530
3	325	Urban Gem	Parcel ID #116414 at the eastern end of Barton Street.	$5,332
4	329	Urban Gem	Parcel ID #117793 south of the eastern end of Truman Street and just north of URB-8 and Rock Creek.	$112,820
5	344	Urban Gem	Parcel ID #132851 on both sides of Rock Creek and north of Athens Avenue near Majestic Drive, just south of Urban Gem Unique ID 329.	$106,844
6	365	Urban Gem	Parcel ID #201990 east of Short Street and south Cecil Street, to the east of Urban Gem Unique ID 324.	$129,781
7	296	Urban Gem	Parcel ID #107729 near the intersection of James Street and Ward Street.	$24,900
8	294	Urban Gem	Parcel ID #107660 just north (upstream) of 15-501 Business where University Drive and 15-501 Business merge.	$57,460
9	362	Urban Gem	Parcel ID #146794 just north and west of Cook Road where Brown Street and Cook Road intersect.	$66,942
10	328	Urban Gem	Parcel ID #117212 near the eastern end of Moline Street to the south and north of Bell Street just east of C.C. Spaulding Elementary School.	$48,135
11	356	Urban Gem	Parcel ID #133264 between the southern end of Hemlock Avenue where it ends at Elmira Avenue and McLaurin Avenue adjacent and to the west of URB-9.	$47,408
12	358	Urban Gem	Parcel ID #133371 just southwest of Elmira Avenue just east of Urban Gem Unique ID 355 at the northern end of Curtis Street.	$42,838

Map ID[1]	Unique ID[2]	Type	Description	20-Year Life Cycle Cost
13	355	Urban Gem	Parcel ID #133263 between the southern end of Hemlock Avenue where it ends at Elmira Avenue and McLaurin Avenue adjacent and to the east of Urban Gem Unique ID 356.	$41,909
14	324	Urban Gem	Parcel ID #116095 east of E. Alton Street and south of Short Street directly west of Urban Gem Unique ID 365.	$33,698
15	323	Urban Gem	Parcel ID #116094 east of E. Alton Street and south of Short Street directly west of Urban Gem Unique ID 324.	$2,628

[1] MAP ID refers to the label used to identify high priority projects in Figure 11.
[2] Unique ID refers to a project specific numbering system implemented following the initial identification of watershed opportunities which were previously assigned as project ID (i.e., SCM or Reach ID) or parcel ID for preservation projects. The Unique ID numbering system spans across project type and is always a three digit number.
[3] Some keystone properties and urban gems may currently be subject to voluntary protection by existing homeowner's association covenants.

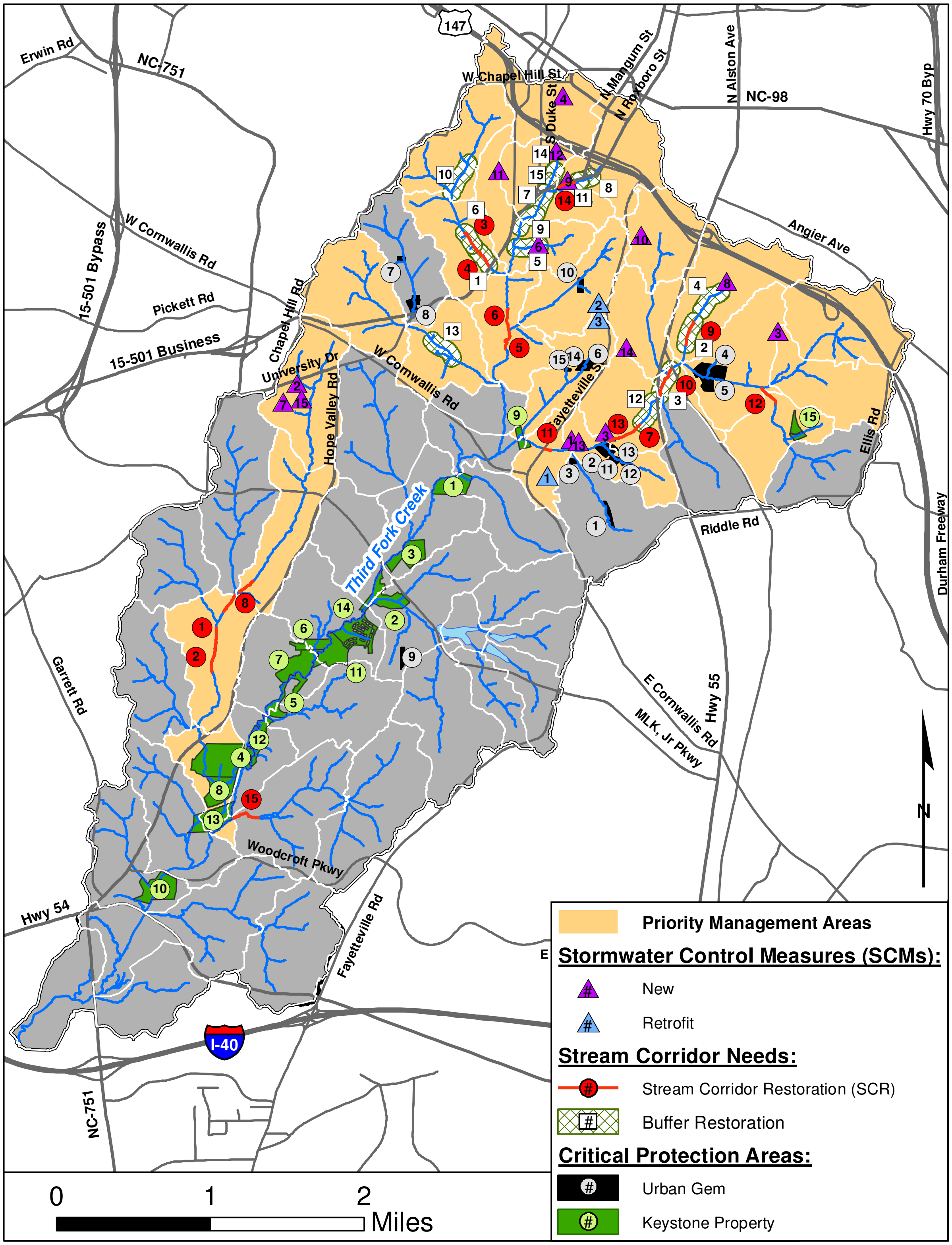

Figure 11. Location of Highest Priority Sites for Implementation (Refer to Table 6 for corresponding list of Map IDs)

6 Implementation Strategy

The success of this WMP depends on maintaining the existing management foundation discussed in Section 4 and new opportunities to improve management of the watershed and water quality as outlined in Section 5. Overall success will also depend on the concerted effort of many regional agencies, community leaders, and local landowners. The recommended actions and enhancement will require significant time and resources on behalf of these organizations. Section 6.1 provides a table recommending key actions to take in the coming decade. Section 6.2 summarizes the cost of implementing the opportunity sites for new structural SCMs for existing development, retrofit of existing SCMs, stream and buffer restoration and enhancement, and critical area protection. It also provides potential sources of funding, and the cost and benefits of the top candidate sites for implementation over the next decade. Section 6.3 discusses indicators that will be used to track the progress of plan implementation and to measure how well the watershed goals and objectives are being achieved.

Implementation capability for this WMP will depend on many factors, including available funding and resources, water quality regulatory requirements, and other community priorities requiring attention in the City's strategic plan. In that regard, the Implementation Strategy outlined in this section should be viewed as potential building blocks on the existing management foundation and a starting point to help guide the City in improving management of the Third Fork Creek watershed.

6.1 Recommended Actions and Responsibilities

Tables 7-9 outline specific management actions recommended in the coming years by their management plan component: new structural SCMs for existing development and retrofit of existing SCMs for water quality; stream and buffer restoration/enhancement; and critical area protection (Table 7); nonstructural SCM enhancements related to public education and involvement (Table 8); and City codes and programs (Table 9). These actions do not represent all activities in the watershed, rather opportunities to enhance existing programs and water quality controls to strengthen overall watershed management.

Success will depend on the concerted effort of many agencies, community leaders, and landowners as well as funding. The timeline for action is approximately 10 years, which generally overlaps with the Third Fork Creek WQRP period (year 2020) and the Jordan Lake Rules Enhanced Stage 2 period (year 2023). However, completion for a number of actions might extend well beyond the next decade.

Table 7. Structural SCM, Restoration, and Protection—Recommended Implementation Actions

Management Plan Component
New Structural SCMs for Existing Development and Retrofit of Existing SCMs
– Final evaluation of administrative feasibility and site selection
– Landowner outreach and easements
– Final planning, design and cost estimates
– Secure needed permits

– Secure funding
– Implement projects and construction
– Monitor effectiveness of SCM retrofits that incorporate design configurations intended to enhance SCM performance in the Triassic Basin relative to standard design criteria
– SCM Maintenance
– Annually update database of potential new SCM sites to show progress of sites implemented and continued viability of remaining sites
Stream and Buffer Restoration and Enhancement [a]
– Final evaluation of administrative feasibility and site selection
– Landowner outreach and easement investigation
– Stakeholder partner identification on a site-by-site basis (Note: A stakeholder partner is one or more entities that wish to conduct stream restoration on the project site. The partner could be another agency, a nongovernmental organization or a private-sector entity that has mitigation needs.)
– Field evaluation and collection of additional data
– Contact the U.S. Army Corps of Engineers, NC Division of Water Quality, and other permitting agencies
– Coordinate with trails and infrastructure
– Coordinate with cultural resources priorities
– Preliminary design and cost estimate
– Secure funding sources
– Secure stewardship organization, as needed, for future ongoing site management
– Final planning and design
– Secure needed permits
– Acquire easements
– Develop stewardship plan including but not limited to monitoring and posting and ongoing management
– Implement projects
– Regularly (e.g., biennially) update database of potential new restoration sites to show progress of sites restored and continued viability of remaining sites
Critical Area Protection
– Final evaluation of administrative feasibility and site selection
– Landowner outreach and easement investigation
– Field evaluation
– Stakeholder partner identification on a site-by-site basis. (Note: A stakeholder partner is one or more entities that wish to acquire the project site. The partner may be another agency, a nongovernmental organization, or a private-sector entity that has mitigation needs.)
– Work with potential partners to secure sites that meet multiple community objectives
– Coordination with cultural resources priorities
– Secure funding sources

– Identify and secure stewardship organizations as needed, for future ongoing site management
– Develop stewardship plan including but not limited to monitoring and posting of the site and ongoing site management as needed
– Purchase property or easement
– Annually update database of potential Critical Area Land sites to show progress of sites acquired and continued viability of remaining sites

[a] Durham County Soil and Water Conservation District is expected to be a cooperating agency.

Table 8. Public Education and Involvement—Recommended Implementation Actions

Management Plan Component
Nonstructural SCMs—Public Education and Outreach
Key Ongoing Activities: – Continue updating Third Fork Creek webpage and Stormwater Services' Facebook page – Continue installing dog waste stations in City parks in watershed – Continue educational presentations to schools, civic organizations, businesses, and neighborhood groups – Continue media campaign on buffer improvements and lawn care – Continue to distribute educational materials to automotive facilities, power washers, yard maintenance, and pool maintenance
Recommended Priority Enhancements: – Beginning in High-Priority Management Area subwatersheds for stream restoration, provide education and assistance to homeowners regarding stream buffer replanting – Beginning in High-Priority Management Area subwatersheds for stream restoration, educate citizens and homeowners' associations on the benefits of stream buffers and no-mow areas – Enhance education, outreach, and certification requirements for professional lawn service providers and large institutional maintenance staff regarding proper use of fertilizer, importance of vegetated buffers, and the need to revegetate bare, eroding areas in turf and lawn (NCDENR and North Carolina Cooperative Extension. Jordan Lake Rules requires fertilizer application by trained professionals or under plan developed by certified professional.)
Other Potential Enhancements as Resources Allow: – Enhance pet waste cleanup education with homeowners in the watershed in High-Priority Management Area subwatersheds – Conduct *Do Not Feed Geese* education as a part of citizen outreach – Develop new educational materials for small scale poultry and composting facilities to ensure they do not impact water quality – Map existing *doggie day care* facilities, veterinary clinics, breeding, boarding and training facilities, groomers, and multi-function pet care stores. Conduct outreach regarding trash enclosure, cleaning waste from outdoor exercise area, and site drainage and landscaping to mitigate contamination in runoff

Nonstructural SCMs—Public Participation and Involvement
Key Ongoing Activities: – Continue to co-sponsor Creek Week and Big Sweep stream cleanups in the spring and fall (co-sponsored by Keep Durham Beautiful) – Continue to recruit participation in City-sponsored rain garden installation and disconnection of impervious area – Continue to use Mayor's summer youth workers and volunteers to prepare and plant rain gardens and disconnect impervious area
Recommended Priority Enhancements: – Evaluate new incentives for disconnecting impervious area (in coordination with Planning Department) – Target impervious area disconnection recruitment efforts in the High-Priority Management Area subwatersheds for impervious area stormwater management – Prioritize stream cleanup efforts in High-Priority Management Area subwatersheds for stream restoration
Other Potential Enhancements as Resources Allow: – Evaluate alternative methods of invasive species control – Consider working with nonprofit organization to add invasive species cleanup to stream cleanup events (including training and mobilizing volunteers for this effort) – Evaluate potential benefit of extending rain catchers program to Third Fork Creek watershed – Evaluate opportunities for removing underused parking areas to create urban amenities such as pocket parks and community gardens (in coordination with Planning Department)

Table 9. City Codes and Programs—Recommended Implementation Actions

Management Plan Component
***City Programs and Codes*—Illicit Discharge Detection and Elimination**
Key Ongoing Activities: – Continue dry weather flow inspection program to identify and eliminate sources of contamination – Continue to maintain and update the stormwater system inventory including stormwater discharge outfalls – Continue to identify and eliminate failing septic systems and sanitary overflows
Potential Enhancements as Resources Allow: – Prioritize illicit discharge detection and elimination program activities in subwatersheds identified as High-Priority Management Areas
City Programs and Codes—Construction Site Runoff Controls
Key Ongoing Activities: – Continue to work with the Durham County Sedimentation and Erosion Control Officer in enforcing UDO construction site runoff requirements

City Programs and Codes—Post-Construction Site Runoff Controls
Key Ongoing Activities: – Continue to enforce City UDO and other code performance standards for nitrogen and phosphorus loading limits, TSS control, peak flow mitigation, stream buffers, impervious area limitations, and other provisions affecting post-construction site runoff – Continue to require an operation and maintenance plan for each new structural SCM – Continue to require owners of structural SCMs to have each SCM inspected by a certified inspector and submit a maintenance inspection report annually to the City – Continue to conduct seminars for engineers, architects, developers, and SCM maintenance professionals
Recommended Priority Enhancements – Develop and pursue approval of Triassic Basin-specific standards for SCMs that are limited by soil infiltration capacity. Such standards will likely vary from DWQ's current generic standards and will provide for optimized performance under local conditions (NCSU and NCDNER) – After new State permeable pavement chapter is added to the state BMP manual, revise or incorporate the chapter into the City's permeable pavement design standards to better suit Durham's hydrologic and soil conditions – Finalize SCM design standards in Durham's Reference Guide for Development (RGD) regarding allowance of bioretention with Internal Water Storage in C and D soils with conditions (in coordination with NCSU, and NCDNER) – Revise the RGD to require use of the *raked method* for constructing the bioretention bottom surface – Consider alternative reduced street widths, such as 20 feet for Residential Limited and Residential Street and 26 feet for Residential Local Street (with on-street parking, one lane) (in coordination with Public Works Department, Engineering Division, Transportation Department, and Planning Department) – Revise street cross-sections, or provide cross-section alternatives, to include water quality treatment devices (in coordination with Public Works Department, Engineering Division, Transportation Department, and Planning Department) – Finalize guidance in the RGD on the proper application, configuration, and uses of rainwater harvest or cisterns
Other Potential Enhancements as Resources Allow: – Revise utility easement clearing and mowing practices, where feasible, for minimal impact in the riparian buffer area (Public Works, Parks and Recreation, General Services) – Pursue DWQ approval of greenroof systems for meeting nutrient removal requirements in the Jordan Lake watershed (in coordination with Local University Researchers and DWQ) – Evaluate additional opportunities for incorporating BSD concepts into development review, including how, when, and where the concepts are appropriate for the City. For example, this could include an evaluation of existing landscaping and screening requirements (in coordination with Public Works Department, Planning Department, Engineering Division, Transportation Department) – Evaluate opportunities to strengthen existing floodplain development regulations (in coordination with Stormwater Division and the Planning Department)
City Programs and Codes—Pollution Prevention/Good Housekeeping for Municipal Operations
Key Ongoing Activities: – Continue street sweeping program – Continue inspections program of municipally-owned or -operated facilities – Continue annual maintenance of City-owned SCMs

Recommended Priority Enhancements:

- Implement a pilot program to assess catch basin materials (e.g., trash, yard waste, sediment) and record catch basin material constituents and build-up levels in certain areas (e.g. metals, oil and grease, nutrients, and bacteria), and develop optimized cleaning schedule based on highest loading areas and pollutant sources
- Develop inspection/maintenance program for SCMs on City property, including development of strategies for SCM maintenance, e.g., MOU or MOA between stormwater and the property manager that clearly spells out and delineates maintenance responsibilities
- Incorporate basic Level of Service statement(s) into the SCM maintenance program documents

Other Potential Enhancements as Resources Allows:

- Make changes to City inspection checklists, certification statement of the SCM maintenance program

City Programs and Codes—WQRPs and Monitoring

Key Ongoing Activities:

- Continue to update the Third Fork Creek WQRP
- Continue to conduct hydrologic monitoring at Woodcroft Parkway
- Continue to conduct ambient chemistry monitoring at select stations
- Continue to conduct special studies as needed

6.2 Cost, Benefits, and Potential Funding

Implementation of the WMP will require funding and sustained support. This section summarizes the key methods and assumptions for estimating the cost of implementing the recommended opportunities, the results of the benefits analysis, and potential sources of funding.

6.2.1 Key Methods and Assumptions for Estimating Costs and Benefits

6.2.1.1 Estimating Costs

The present value of the estimated life cycle costs was developed for proposed structural SCMs, stream restoration, buffer restoration, and critical area protection implementation. Developing cost estimates generally followed the methods used in the Ellerbe Creek WMIP so that the related prioritization scores for proposed SCMs would be comparable regardless of watershed. Because of variations in available sites, proposed SCM types, analysis methods, and other factors, a number of modifications were made.

Base Construction Costs were determined using a unit item cost method in which a list of probable construction items and their associated quantities was developed for each SCM. The items and unit costs generally followed those used in other City of Durham watershed planning efforts. Construction items and their associated unit costs were generally classified in one of two categories—fixed and variable. Fixed quantities are those items that would not be expected to vary significantly from site to site, such as materials required for construction site access points (e.g., the required stone and geotextile underlayer). Variable quantities are those items whose construction quantities would necessarily vary dependent on SCM size and features such as excavation, grading, and permanent seeding. A variety of cost contingencies were computed for each site to account for items that were not included in the construction quantities estimate. These contingencies included erosion and sedimentation control, mobilization, construction administration, and construction. The construction cost subtotal for each project was computed by summing each of the contingencies listed with the base construction cost for the site.

Constructability Factor: Preliminary construction costs based on quantities as described above are subject to significant variability due to the uncertainty in the estimation of quantities. This uncertainty results from the relative lack of site-specific information beyond site visits and available GIS resources for the planning project. To address this uncertainty, a constructability factor was applied to each site. This factor, ranging from 0 to 2, is intended to account for non-quantifiable cost impacts as observed by the field crews. For example, a site whose topography naturally reduces the need for extensive excavation and off-site spoil disposal would likely result in a reduced construction cost relative to the construction costs based on quantities estimation that uses excavation quantities by SCM footprint. The final construction cost estimate was computed by multiplying the construction cost subtotal with the constructability factor.

Engineering and Permitting: Costs for engineering and permitting were based on the methods used in the City's other watershed planning projects. Costs were scaled to construction costs with a series of minimum threshold values dependent on relative SCM cost, with the lowest threshold being $65,000.

Acquisition Cost: Costs for acquisition or easement of property to construct SCMs, stream restoration, and buffer restoration were based on a portion of the assessed tax value of those parcels on which the proposed project is located. The portion of assessed parcel value was determined by the area necessary to construct and maintain each project relative to the total parcel area. Different assumptions were made depending on the management practice type. For SCM retrofit projects, it was assumed that an area of twice the SCM footprint would be necessary for implementation. For stream projects, it was assumed that an area consisting of the restoration reach length and an associated corridor width of 100 feet (i.e., 50 feet on each side of the stream) is necessary for implementation. Stream and buffer restoration costs included acquisition of a 50-foot-wide buffer on each side of the restored stream reach. For critical area protection projects (i.e., Keystone Properties and Urban Gems; see Appendix N), costs of acquisition were based on purchase of the entire parcel on which the critical land is located (again assuming assessed tax value). These acquisition costs are conservative because in some cases the City may be able to secure an easement or donation of land for less than the assessed tax value, and the entire parcel containing critical lands may not need to be acquired.

20-Year Operation and Maintenance (O&M) Costs: Annual O&M costs were estimated as a percentage of construction cost, depending on SCM type. Twenty-year O&M costs were computed by assuming an average annual seven percent interest rate over the period.

Endowment Costs for open space easement properties often include annual monitoring costs that take into account staff time, travel costs, supplies, posting of boundary markers, and site or easement management costs. Endowment costs for a property purchased in full could include similar annual monitoring costs, but could also include costs for any future obligations for the property such as building recreation facilities or trails on properties that would be designated as public access parks. A series of rules were developed to estimate endowment cost for each open space preservation opportunity in the Third Fork Creek watershed. These rules factor in relative project size and calculated land acquisition cost. On the basis of best professional judgment, a maximum endowment cost of $20,000 was selected for this analysis.

More detailed information on cost methods and assumptions are in Appendix G, SCM Retrofit and Stream Opportunity Analysis.

6.2.1.2 Estimating Benefits

Structural SCMs. The Third Fork Creek SWMM model was used to estimate the benefits of the recommended SCMs. The tool was configured to be consistent with DWQ’s Jordan/Falls Lake tool methods because these state-driven methods and assumptions will be used in the future to test compliance with the Jordan Lake Rules. The SWMM tool used a runoff volume allocation method paired with pollutant effluent concentrations. Inflow to an SCM was directed to three pathways—treatment, overflow, and loss (from infiltration or evapotranspiration). Load from the treatment volume was calculated using a fixed effluent concentration associated with each SCM practice (based on the median concentration from SCM monitoring data for the pollutant of concern and practice type). Table 10 has treated effluent concentrations for TN and TP for each type of practice represented. For TSS and Copper, the International Stormwater BMP Database was used to develop representative median effluent concentrations for each practice type. Insufficient data were available to develop effluent concentration for bacteria, so percent removal values from those used in earlier watershed planning efforts were used. Pollutant-removal performance was simulated using the effluent concentration approach (and percent removal for fecal coliform bacteria) for stormwater wetlands, wet ponds, extended dry detention basins, bioretention, the tree box, and the vegetated filter strip. The median effluent concentrations and percent removal values are shown in Table 10. For rainwater harvesting and permeable pavement, pollutant removal performance was associated with volume loss pathways only.

Table 10. SCM Median Effluent Concentrations

SCM Type	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L	Copper (ug/L)	Fecal Coliform Bacteria %
Stormwater Wetland	1.08	0.12	15.9	5.0	50%
Wet Pond	1.01	0.11	16.0	5.0	50%
Extended Dry Detention	1.20	0.20	23.2	17.5	20%
Bioretention With IWS[a]	0.95	0.12	12.9	4.6	60%
Tree Box	1.00	0.12	12.9	4.6	60%
Vegetated Filter Strip	1.20	0.15	20.0	8.8	20%

[a] IWS (internal water storage) is the term used in the North Carolina BMP manual to indicate fill below the underdrain for allowing infiltration.

Stream Restoration/Enhancement: The estimated benefits of stream restoration and enhancement projects include the direct reduction in sediment load due to stabilization of stream erosion plus the treatment of upstream load. Sediment load reduction was based primarily on methods used for the Ellerbe Creek WMIP. The methods include an estimated pre-restoration erodibility rate as a function of regional discharge curves, existing channel geometries and Unified Stream Assessment scores determined during field investigations (Appendix B). The method is based on the assumption that a base level of sediment production (for a given soil type), expressed as pounds per square foot per year ($lb/ft^2/yr$), will vary according to the amount of vegetation cover and hydrodynamic variation.

To estimate total in-stream TSS production, total erosion per square foot of streambank was first calculated using the following equation:

$$\text{Bank Erosion } (lb/ft^2/yr) = \text{BaseErosionRate} \times \text{Erodibility} \times \text{Erosivity}.$$

A value of 6 $lb/ft^2/yr$ was used for the BaseErosionRate based on the Ellerbe Creek WMIP. Stream bank erodibility, defined as a bank's susceptibility to erosion by channel shear stress, was calculated using the qualitative *Bank Erosion* criteria measured during the stream field assessments. Erosivity of streamflow quantifies the potential magnitude of the streams ability to erode bank sediment relative to 1-year discharge for undeveloped, rural watershed conditions. After the unit bank erosion rates were calculated for each reach using erosivity, erodibility, and the base erosion rates, the total in-stream TSS production was calculated for a length of stream using the following equation:

$$\text{TSS Production (lbs/yr)} = \text{Bank Erosion } (lb/ft^2/yr) \times \text{Bank Height (ft)} \times \text{Bank Length (ft)}.$$

Stream restoration or enhancement can reduce in-stream sediment loads by stabilizing stream banks and reducing bed scour. Potential reductions in TSS production were estimated by reducing the erodibility values to a *healthy* stream value. In reality, a stable restored reach will never have zero percent bank erosion, so a restored erodibility value of 14.5 percent for all restoration reaches was assumed. In-stream TSS reduction was then calculated as follows:

In-Stream TSS Reduction = Existing TSS Production - Restored TSS Production.

The efficiencies of stream restoration at removing upstream load were based on literature review for the Ellerbe Creek WMIP. The efficiencies are in Table 11. For more detail on the methods used to estimate the benefits of stream restoration and enhancement, see Appendix G.

Table 11. Estimated Pollutant-Removal Efficiency for Stream Projects

Pollutant	Efficiency (lb/linear foot)
Total Nitrogen	0.02
Total Phosphorus	0.0035
TSS or Sediment	2.55

Source: Ellerbe Creek WMIP

Critical Area Protection: Quantifying the benefits of critical area protection involves estimating the pollutant load avoided if development had been able to occur on the site rather than preserving it as a forested area. Therefore, the first step in estimating benefits is determining zoning and other code requirements and the subsequent developable portion of the parcel.

For developable portions of each critical area parcel, the watershed modeling results shed light on the benefits of pollution and runoff prevention from preservation of critical lands. For example, if the zoning for a particular parcel allows medium density residential development, then developing the land would generate more than double the TN runoff and more than triple the TP runoff than preserving the land in forest (see Table 12). If zoning allows commercial development, it would generate approximately 4 times the TN and 6 times the TP as preserving it in forest. The table shows that preservation of land can significantly reduce sediment as well.

Table 12 provides loading rates for nutrients and sediment on the basis of analyses using the Third Fork Creek SWMM model, introduced in Section 1.4. The forest loading rates were generated assuming the entire watershed was in a forested condition; the ranges reflect the minimum and maximum loading rates among the 60 model subwatersheds that have variable slope and Hydrologic Soil Group (HSG), which is a soil characteristic that defines how well soils support infiltration. The developed loading rates were taken from an analysis of projected future conditions in the watershed (called the Future Baseline analysis); each land use was simulated with treatment SCMs designed to achieve compliance with the City's stormwater ordinance. The minimum and maximum values reflect the range of expected post-treatment pollutant loading, based on combinations of HSG and peak-flow matching requirements. Further details regarding the developed land use configurations and assumptions are in the *Third Fork Creek Watershed Modeling Report* (See Appendix J).

In the future, for each parcel targeted for acquisition, pollutant loading prevention can be estimated by matching the current zoning of the property to the appropriate land use category in Table 12. Multiply the acres by the loading (e.g., TN lb/ac/yr) for both the zoned land use and the preserved open space for the area of the property that otherwise could have been developed. Continuing with the medium density residential example, if a 5-acre parcel in this zoning category has 1 acre falling within a buffer zone that allows no development, the City would multiply the 4 developable acres by the medium density residential development loading rates and then by the forest area loading rates. The difference between the two will yield the loading reduction benefit. So for TN in our example, the minimum benefit expected is a loading reduction of 3.72 lb/yr (from 4 acres of medium residential multiplied by 2.01 lb/ac/yr TN reflecting the lower end of the loading range, minus 4 acres of forest at the higher loading rate of 1.08 lb/ac/yr TN). The maximum benefit expected is a loading reduction of 6.88 lb/yr TN (calculated using the upper end loading rate of 2.69 lb/ac/yr TN for medium residential cover, and the lower end loading rate of 0.97 lb/ac/yr TN from forest cover).

Table 12. Pollutant Loading Rates for Forest and Developed Land Uses[a]

Land Use	Range	Total Nitrogen lb/ac/yr	Total Phosphorus lb/ac/yr	Total Suspended Solids ton/ac/yr
Forest	Lower	0.97	0.066	0.0064
	Upper	1.08	0.074	0.0076
Low-Density Residential	Lower	1.62	0.151	0.0094
	Upper	2.10	0.207	0.0141
Medium-Density Residential	Lower	2.01	0.201	0.0134
	Upper	2.69	0.261	0.0183
Institutional	Lower	2.73	0.268	0.0196
	Upper	3.47	0.338	0.0246
Office	Lower	3.19	0.326	0.0233
	Upper	3.80	0.389	0.0279
Industrial	Lower	3.58	0.371	0.0278
	Upper	4.21	0.439	0.0333
Commercial	Lower	4.07	0.426	0.0316
	Upper	4.80	0.487	0.0366

[a] Loading rates for developed land uses include an scm treatment assumption based on current regulations (e.g., regular TN developed land area loading rate minus 40% or 2.2 lb/ac/yr, whichever is higher)

Forested Stream Buffer: Forested stream buffers provide many benefits for water quality, including the ability to reduce pollutant loading entering streams. Buffers potentially filter and treat runoff entering them as sheet flow, and also may remove nutrients from shallow groundwater. There are numerous monitoring studies that show buffer pollutant removal is strongly correlated with the width of the buffer—narrow buffers remove relatively less pollutant mass than wide buffers, all other things being equal. However, the majority of pollutant mass appears to be removed within the first 30 feet. Another important factor influencing buffer performance is the concept of the buffer treatment zone. Buffers treat runoff that enters them as sheet (or overland) flow. Runoff that enters as concentrated flow bypasses the buffer and flows directly to the stream without filtration. Sheet flow tends to become concentrated flow over short distances, especially in urban areas; the maximum distance over pervious surfaces is probably not more than 300 feet. As a result, buffers are given credit for treating an average 150-foot band around the outside of the buffer (the buffer treatment zone).

Proposed buffer restoration projects for prioritization evaluation are assumed be 50 feet wide on each side of the stream. Using guidance from a buffer performance summary study and from the Center for Watershed Protection, a 50-foot buffer is assumed to remove the following percentages of pollutant mass entering as overland flow from adjacent developed land: Total Nitrogen - 31 percent; Total Phosphorus - 38 percent; Sediment - 62 percent. Derivation of the performance values is discussed further in Appendix G. GIS was used to calculate the extent of 50-foot buffers adjacent to proposed buffer restoration streams (see Table 20 for the total area of the buffer restoration project opportunity sites in the watershed). The buffer treatment zone was then calculated as the area adjacent to each buffer, moving 150 feet away from the stream. Land use in the buffer treatment zone was tabulated individually for each project. Loading rates for developed land uses were estimated using the Third Fork Creek SWMM watershed model, and load reductions for each buffer project were calculated using the land use area, the loading rates, and the percent removal values shown above. It is important to note that this analysis assumes all flow enters the buffer as sheet flow and not concentrated flow, and that well-constructed, appropriate landscape controls or level spreaders would be used and maintained to ensure runoff enters the restored buffers as diffuse flow.

6.3 Estimated Cost and Benefits of Project Implementation

The cost for some of the key Implementation Strategy components are summarized below, including the cost of implementing opportunity sites for new structural SCMs, existing SCMs for retrofit, stream and buffer restoration/enhancement, and critical area protection for both Keystone Properties and Urban Gem Sites. Estimated costs and benefits are provided for implementing the 15 top ranked sites in each of these categories (with the exception of SCM retrofit sites for which few opportunities were identified). The SCM and stream and buffer restoration costs are based on site specific cost estimates developed using limited site information and configuration assumptions. In addition, the sites were limited to opportunities identified during field screening. As a result, the costs may not be fully representative of costs for implementation throughout the watershed and may vary from costs reported by other sources. More detailed unit costs are provided for each type of structural SCM recommended (e.g., bioretention, stormwater wetland). Potential sources of funding are also provided for each category.

Existing and New Potential Funding Sources: Existing Sources—City of Durham Stormwater Management Fund, City of Durham Impact Fees (for recreation and open space; to be used as outlined in City Code), Section 319 Grants, EPA Sustainable Community and Brownfield Grants, Triangle Land Conservancy; Potential New Sources—Highway Project Mitigation Needs for U.S. Department of Transportation (USDOT) and North Carolina Department of Transportation (NCDOT), NC Clean Water Management Trust Fund, NCDENR Water Quality Revolving Loan Fund, US Army Corps of Engineers General Investigations, Development Agreements, and Tax Increment Financing.

6.3.1 New Structural SCMs for Existing Development

Table 13. Cost Summary for All Identified New Structural SCM Opportunities

Total Number of Properties	45 parcels
Total Number of Acres Treated	499 acres
Total Impervious Acres Treated	232 acres
Implementation Cost (Engineering and Design, Land Acquisition, And Construction)	$11.7 million
20-yr O&M Cost	$2.8 million
Total Cost[a]	$14.5 million
Median Cost Per Treated Acre	$119,024 per acre[b]
Median Cost Per Treated Impervious Acre	$261,374 per acre

[a] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.
[b] See unit cost below for individual types of SCMs

Table 14. Top 15 New Structural SCM Opportunities - Estimated Cost and Benefits

Total Implementation Cost	$3,581,396[a,b]
Estimated Benefits in Load Reduction	258 lbs/yr TN 15 lbs/yr TP 5,105 lbs/yr TSS
Median Cost Per Pound of Pollutant Removed Per Site	$17,467/lb/yr TN reduced $440,949/lb/yr TP reduced $1,241/lb/yr TSS reduced

[a] See unit cost in Table 15 below for individual types of SCMs
[b] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.

Table 15. Unit Cost for Types of Structural SCMs

SCM	Quantity	Median Implementation[a] Cost Per Pound of Nitrogen Removed	Median Implementation[a] Cost Per Acre Treated	Median 20-Yr O&M Costs Per Acre	Median Total Cost Per Acre Treated
Bioretention Area[b]	19	$24,955	$178,042	$51,684	$241,888
Stormwater Wetland	11	$13,679	$30,562	$9,305	$38,206
Wet Pond	4	$8,839	$20,369	$5,494	$25,862
Porous Concrete/Sand Filter System[c]	3	$94,092	$1,712,531	$81,592	$1,784,016

SCM	Quantity	Median Implementation[a] Cost Per Pound of Nitrogen Removed	Median Implementation[a] Cost Per Acre Treated	Median 20-Yr O&M Costs Per Acre	Median Total Cost Per Acre Treated
Pond Retrofit	3	$14,042	$18,426	$3,077	$23,174
Rain Water Harvesting System	2	$18,561	$81,889	$48,313	$130,203
Linear Detention[d]	1	$2,266	$15,017	$5,315	$20,332
Tree Box Filter[e]	1	$27,359	$282,209	$12,010	$294,219
Level Spreader and Vegetated Filter Strip	1	$61,332	$184,784	$40,224	$225,008

[a] Implementation cost includes construction, engineering and design, and land acquisition.
[b] Bioretention SCMs incorporate IWS and are oversized to maximize water quality treatment. As a result, the costs may be higher than commonly reported for new development. Average construction costs are $22 per square feet of filter bed area.
[c] Costs impacted by high land acquisition costs. Average construction costs are $17 per square feet of permeable surface.
[d] Series of extended detention cells constructed in an area where a single SCM was not possible.
[e] Cost includes $17,500 for tree box construction and the lower threshold for engineering and design ($65K) consistent with cost assumptions from the City of Durham's Ellerbe Creek WMIP.

6.3.2 Existing SCMs for Retrofit

Table 16. Cost Summary for Identified SCM Retrofit Opportunities

Total Number of Properties	6 parcels
Total Number of Acres Treated	107 acres
Total Impervious Acres Treated	42 acres
Implementation Cost (Engineering and Design, Land Acquisition, and Construction)	$1.0 million
20-yr O&M Cost	$0.4 million
Total Cost[a]	$1.4 million
Median Cost Per Treated Acre	$23,353 per acre
Median Cost Per Treated Acre	$23,353 per acre
Median Cost Per Treated Impervious Acre	$70,831 per acre

[a] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.

Table 17. Top 3 SCM Retrofit Opportunities - Estimated Cost and Benefits

Total Implementation Cost[a]	$316,494
Estimated Benefits in Load Reduction	11 lbs/yr TN 1.1 lbs/yr TP 405 lbs/yr TSS
Median Cost Per Pound of Pollutant Removed Per Site	$23,285/lb/yr TN reduced $474,015/lb/yr TP reduced $932/lb/yr TSS reduced

[a] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.

6.3.3 Stream and Buffer Restoration/Enhancement

Table 18. Cost Summary for Stream Restoration/Enhancement Opportunities

Total Number of Stream Reaches	53
Total Length of Restoration/Enhancement Opportunity	42,653 feet
Implementation Cost (Engineering And Design, Land Acquisition, and Construction)	$27.6 million
20-yr O&M Cost	$8.0 million
Total Cost[a]	$35.7 million
Median Cost Per Linear Foot Restored/Enhanced	$797 per foot

[a] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.

Table 19. Top 15 Stream Restoration/Enhancement Opportunities[a] - Estimated Cost and Benefits

Estimated Implementation Cost[b]	$9,857,160
Estimated Benefits in Load Reduction	248 lbs/yr TN 43 lbs/yr TP 1,623,682 lbs/yr TSS
Median Cost Per Pound of Pollutant Removed Per Site	$39,482/lb/yr TN reduced $225,560/lb/yr TP reduced $8/lb/yr TSS reduced

[a] Note that 10 of the top 15 stream projects were also recommended to include buffer restoration. The cost and benefits of buffer restoration are not included in this table (summarized in the tables below). However, it is anticipated that project costs would be lower if stream and buffer restoration projects are implemented together for coincident reaches.
[b] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.

Table 20. Cost Summary for Buffer Restoration/Enhancement Opportunities

Total Number of Buffer Reaches	30
Total Length of Restoration/Enhancement Opportunity	26,447 feet
Total Area of Restoration/Enhancement Opportunity (assumes 50-ft buffer on each side of stream)	26,447,000 ft^2
Implementation Cost (Engineering and Design, Land Acquisition, And Construction)	$7.0 million
20-yr O&M Cost	$0.2 million
Total Cost[a]	$7.2 million
Median Cost Per Linear Foot Restored/Enhanced	$260 per foot
Median Cost Per Square Foot Restored/Enhanced	$2.54 per ft^2

[a] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.

Table 21. Top 15 Buffer Restoration/Enhancement Opportunities - Estimated Cost and Benefits

Total Implementation Cost[a]	$3,363,811
Estimated Benefits in Load Reduction	125 lbs/yr TN 10 lbs/yr TP 4,632 lbs/yr TSS
Median Cost Per Pound of Pollutant Removed Per Site	$1,531/lb/yr TN reduced $18,875/lb/yr TP reduced $41/lb/yr TSS reduced

[a] Total cost is in 2012 dollars and includes engineering and design, land acquisition, construction, and 20-year O&M. See Section 6.2.1.1 for more detail. Based on cost assumptions from the City of Durham's Ellerbe Creek WMIP with modifications and additions as needed.

6.3.4 Critical Area Protection

Table 22. Cost Summary for Identified Keystone Property Opportunities

Total Number of Properties	123 parcels
Total Number of Acres Preserved	754 acres
Implementation Cost (Land Acquisition)	$41 million
20-yr O&M Cost	$1.5 million
Total Cost[a]	$43 million
Median Cost Per Acre Preserved	$58,000 per acre

[a] Total implementation cost is in 2012 dollars and includes land acquisition for the entire parcel and 20-year O & M. See Section 6.2.1.1 for more detail.

Table 23. Top 15 Keystone Property Opportunities - Estimated Cost and Benefits

Total Implementation Cost[a]	$11,714,904
Estimated Benefits in Load Reduction	See note below[b]

[a] Total implementation cost is in 2012 dollars and includes land acquisition for the entire parcel and 20-year O & M. See Section 6.2.1.1 for more detail.
[b] Benefits are dependent on site zoning. No approved accounting method is available. A suggested way to calculate benefits is as follows. For each parcel targeted for acquisition, pollutant loading prevention can be estimated by matching the current zoning of the property to the appropriate land use category in Table 12. Multiply the acres by the loading (e.g., TN lb/ac/yr) for both the zoned land use and the preserved open space for the area of the property that otherwise could have been developed. The difference between the two annual loads is the load avoidance benefit from preservation.

Table 24. Cost Summary for Identified Urban Gem Site Opportunities

Total Number of Properties	78 parcels
Total Number of Acres Preserved	99 acres
Implementation Cost (Engineering And Design, Acquisition, And Construction)	$5.8 million
20-yr O&M Cost	$0.78 million
Total Cost[a]	$ 6.6 million
Median Cost Per Acre Preserved	$80,000 per acre

[a] Total implementation cost is in 2012 dollars and includes land acquisition for the entire parcel and 20-year O & M. See Section 6.2.1.1 for more detail.

Table 25. Top 15 Urban Gem Site Opportunities - Estimated Cost and Benefits

Total Implementation Cost[a]	$901,950
Estimated Benefits in Load Reduction	See note below[b]

[a] Total implementation cost is in 2012 dollars and includes land acquisition for the entire parcel and 20-year O & M. See Section 6.2.1.1 for more detail.
[b] Benefits are dependent on site zoning. No approved accounting method is available. A suggested way to calculate benefits is as follows. For each parcel targeted for acquisition, pollutant loading prevention can be estimated by matching the current zoning of the property to the appropriate land use category in Table 12. Multiply the acres by the loading (e.g., TN lb/ac/yr) for both the zoned land use and the preserved open space for the area of the property that otherwise could have been developed. The difference between the two annual loads is the load avoidance benefit from preservation.

6.4 Tracking and Evaluating Progress

A systematic and well-defined method for tracking and evaluating the progress of project implementation is a key component to a comprehensive WMP. The following recommended tracking indicators would provide another measure of performance that is separate from the *assessment* indicators (Section 2) used to characterize impacts and sources of those impacts in Third Fork Creek watershed. The *tracking indicators* are designed for regular use by the City of Durham's watershed management team during implementation of the plan; whereas the assessment indicators are used to aid in development of the plan. Tracking indicators are used to quantify the components used to measure the success of the goals and objectives from the watershed plan. Also, they provide for qualitative monitoring and comparison of projects and overall watershed condition. Tracking indicators will include scientifically-based measurements (such as in-stream flow, the in-stream concentration of constituent pollutants, and the biological health of stream) and programmatic indicators (such as number of retrofit SCMs installed, length of stream restoration restored, area of open space protected, etc.).

Recommended tracking indicators are proposed in Table 26. The table also provides a description of the method or protocols to be used and the sources of recommended data (all of which are currently collected by the City of Durham Stormwater Services or other agencies).

Table 26. Description and Data Sources of Recommended Tracking Indicators

Tracking Indicators	Description	Data Source
Benthic Communities	North Carolina Biotic Index (NCBI)	City of Durham monitoring data
Aquatic Habitat	NCDWQ habitat assessment method or Rapid Bioassessment Protocol Habitat Score or a similar method	City of Durham team assessment field observations and North Carolina DWQ habitat assessments
Stream Flow Statistics	Flow statistics including but not limited to high-pulse count and high-pulse duration e.g., the Nature Conservancy method, the Bledsoe (2007)[a] or similar methods	Stage/flow measurements from USGS gage and/or City of Durham monitoring data
Water Quality Index	Using concentrations of biochemical oxygen demand, TP, TN, fecal coliform bacteria, copper, zinc, dissolved oxygen, and turbidity	City of Durham monitoring data
Trends Analysis	Appropriate statistical methods e.g., monotonic trends, step trends	City of Durham and other ambient monitoring data
Nutrient Loads	Watershed outlet loads calculated using measured TN, TP, and discharge Estimated SCM nutrient load reduction. Pre- and post SCM load calculated using the Jordan/Falls Accounting Tool	City of Durham monitoring data and USGS discharge data

[a] Bledsoe, Brian P., Michael C. Brown, and David A. Raff, 2007. GeoTools: A Toolkit for Fluvial System Analysis. Journal of the American Water Resources Association (JAWRA) 43(3):757-722. DOI: 10.1111/j.1752-1688.

The programmatic indicators are differentiated from the tracking indicators because they are influenced by regulatory and program-related reporting requirements. As described throughout this WMP, the City of Durham is subject to various regulations which require regular reporting of data and program information. Example management projects and recommended programmatic indicators for the type of project or management practice are in Table 27.

As projects are chosen and quantifiable indicators are developed it is important to consider the regulatory reporting requirements. These include frequency of reporting (monthly, annual, bi-annual, etc.) and measures of progress, such as percent completion (e.g., percent watershed area treated) versus direct measures (e.g., length of stream restored). Existing and future projects may be tracked, but projects implemented through the WMP should be differentiated from other watershed projects to better demonstrate and measure plan implementation. Data for these programmatic indicators will likely come from GIS analysis, as-built drawings, and Stormwater Services staff reports.

Table 27. Recommended Programmatic Indicators for the Third Fork Creek Watershed

Type of Management	Programmatic Indicator
Stormwater SCM	Drainage area treated, impervious area treated (report by type of SCM), water quality benefits (e.g., lbs of TN, TP, and TSS reduced)
Stream Restoration	Length restored, acres of floodplain reconnected; report by type of restoration or enhancement
Riparian Buffer Restoration[a]	Area restored, length of revegetated streambank; report by zones: 0 to 30 feet, 30 to 50 feet, 50 to 100 feet, etc.; Length of stream area preserved
Open Space or Riparian Buffer Protection	Area in watershed permanently protected; riparian area protected (for riparian area protected, report by zones: 0 to 30 feet, 30 to 50 feet, 50 to 100 feet, etc.).
Other Sustainable Practices	# LID practices installed (e.g., rain gardens, rain barrels) # Miles of stream cleanup # Tons trash collected in stream cleanups # Tons trash collected in street sweeping # Pounds trash collected in catch basin cleaning # Pet waste stations installed # Sustainable Landscape Workshops # Adopt-A-Stream events

[a]Buffer preservation and restoration should be tracked separately from stream restoration even when they are part of the same project.

The Implementation Strategy outlined in Section 6, has recommended actions to improve the quality of Third Fork Creek and its watershed. These recommendations guide the City by providing management options, field supported data, and methods to track performance of efforts. The City should periodically review and revise these key actions as new information is available, experience is gained, and success is achieved.